

Octo-Channel High Voltage Power Supply v1.0

User's manual

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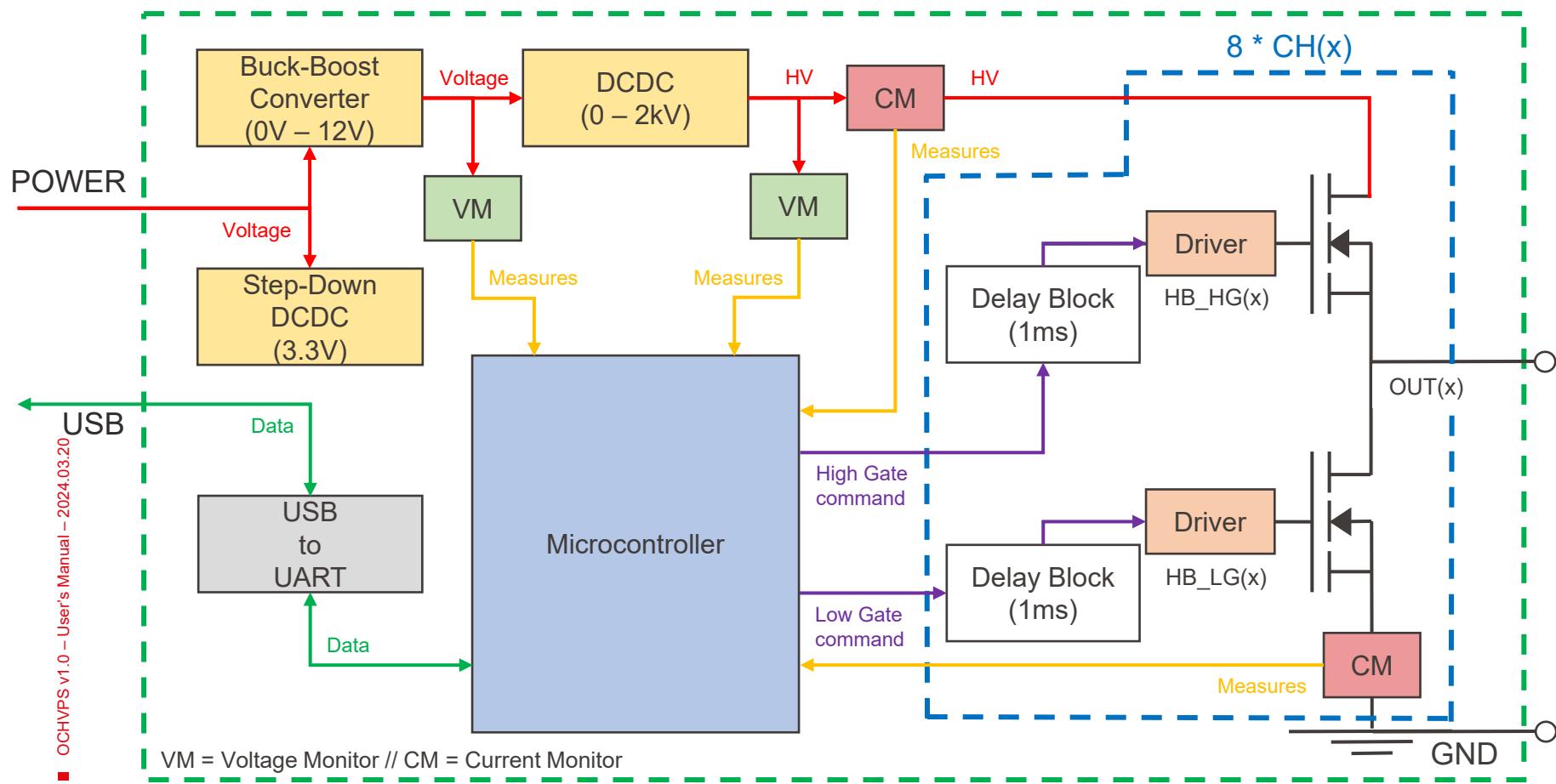
For any question: ochvps@proton.me

Hardware – Specifications

- 10W DC/DC converter
 - Communication with USB port
 - 8 channels, realized with MOSFETs, can be used:
 - 8 Half-Bridges (DC or Unipolar switching),
 - 4 Full-Bridges (Bipolar switching)
 - Voltage measurement:
 - Before DCDC (Low Voltage)
 - After DCDC (High Voltage)
 - Current measurement:
 - At DCDC output
 - In each Half-Bridge
- Weight (with enclosure): 725 g
 - Dimensions (with enclosure):
 - Length: 30.5 cm
 - Width: 15.5 cm
 - Height: 4.0 cm

Characteristics		min	typical	max	unit
Inputs	USB Input voltage (Standard USB)	4.5	5	5.5	V
	USB Input current			500	mA
	Jack Input voltage	10	12	14	V
	Jack Input current			2	A
Outputs	Number of Channels	8 Half-Bridge // 4 Full-Bridges			
	Polarity	Unipolar or Bipolar			
	Output Voltage	0		2000	V
	Output Voltage resolution	12			bits
	Output Frequency	0.01		1000	Hz
	Output Current (short circuit to ground)			5	mA

Hardware - Architecture

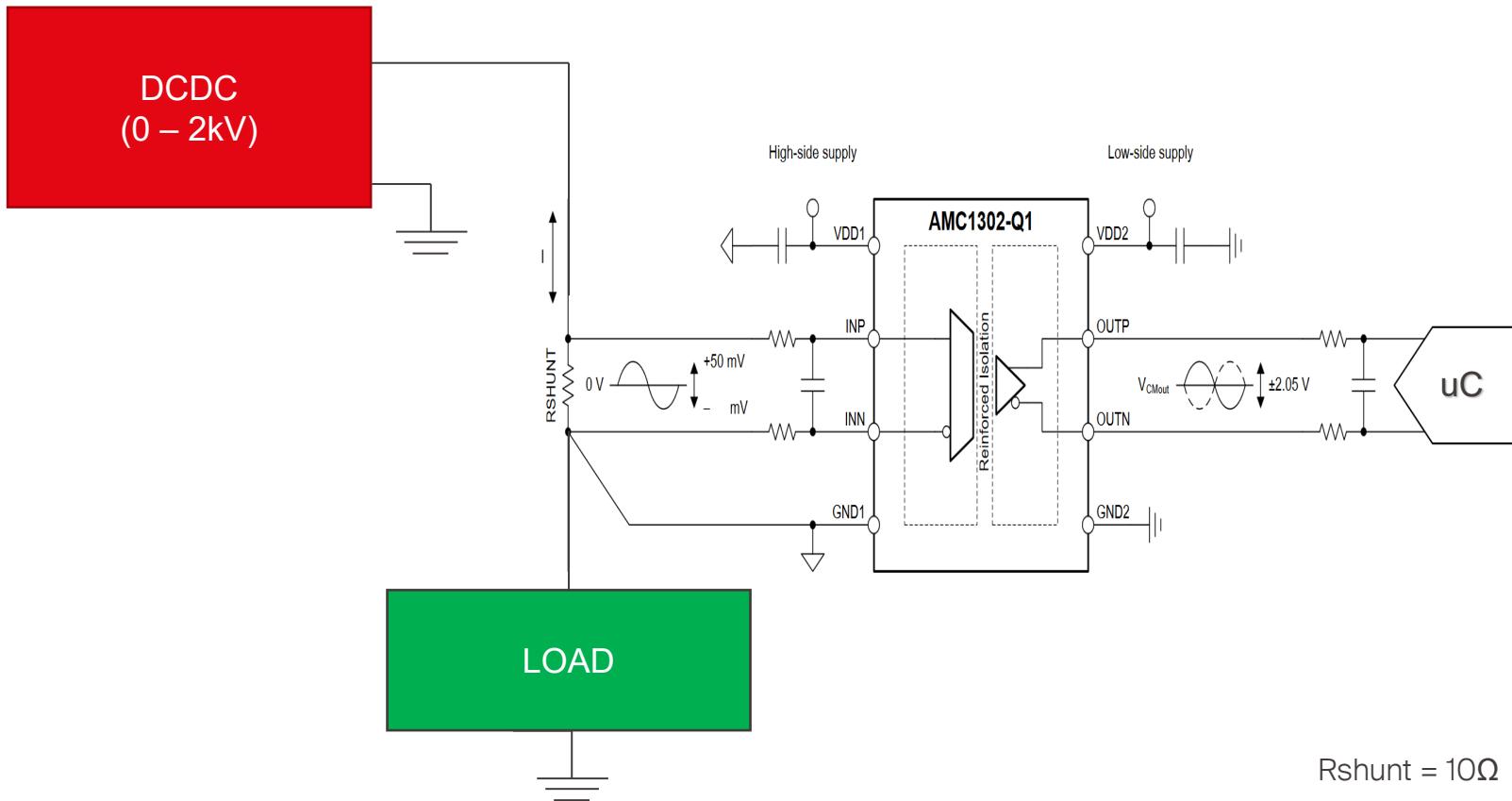


Hardware - High-Side Current Measurement (HV_CM)

- Implemented solution: [AMC1302-Q1](#)
 - Precision, isolated amplifier
 - Output separated from the input by an isolation barrier (up to 5kV)
 - Supply Voltage: 5V on high-side / 3.3V on low-side
 - Fixed gain: 41
 - Offset error: $\pm 50 \mu\text{V}$
 - Gain error: $\pm 0.2 \%$
 - Differential output
 - Maximal current expected: 5mA
 - Maximal voltage given by the amplifier: 2.05V
- Specifications for the ADC used inside the microcontroller:
 - Resolution: 16-bits ($0.75 \mu\text{A}/\text{bit}$)
 - Sampling rate: 20 Ksps

Hardware - High-Side Current Measurement (HV_CM)

- Block diagram:

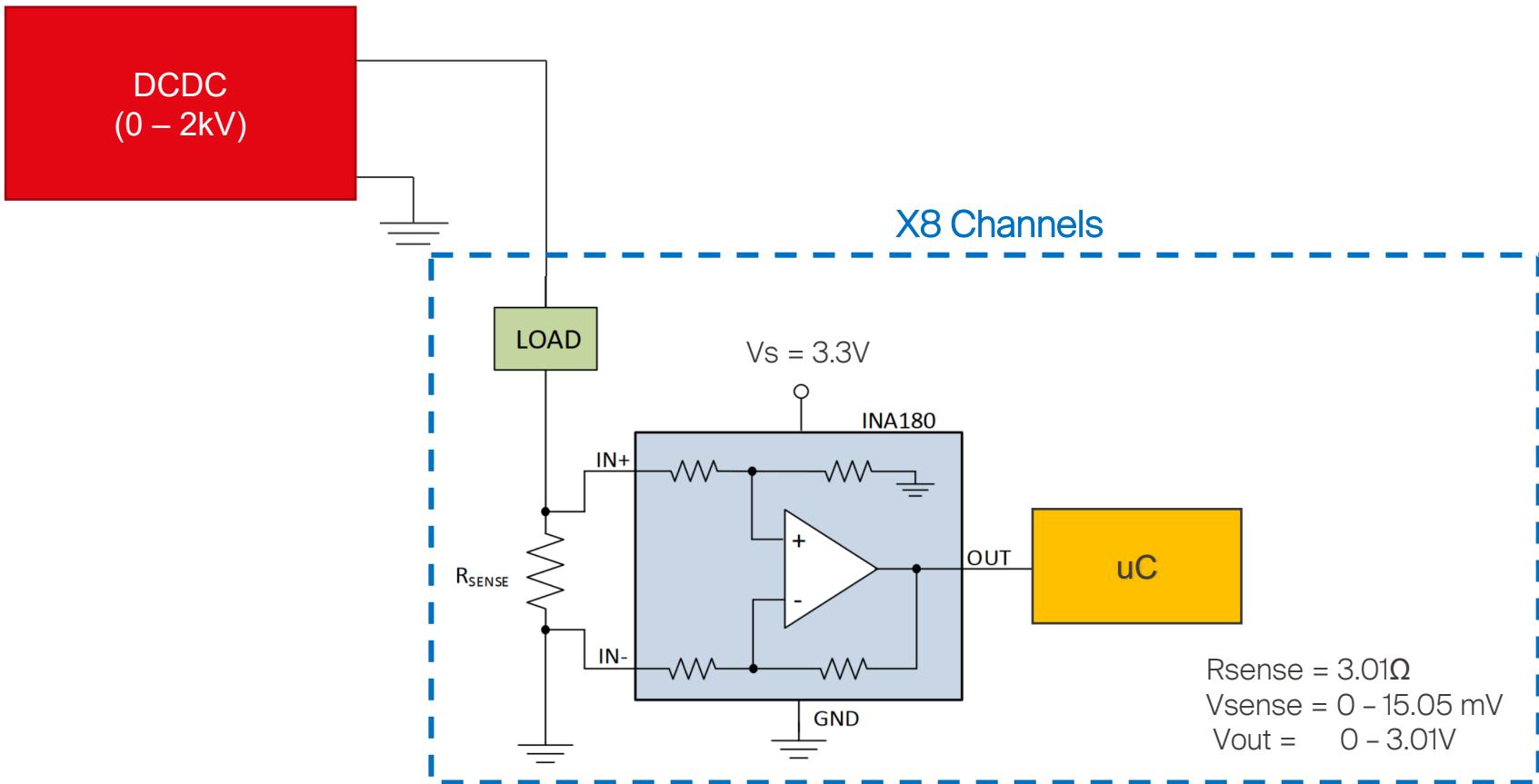


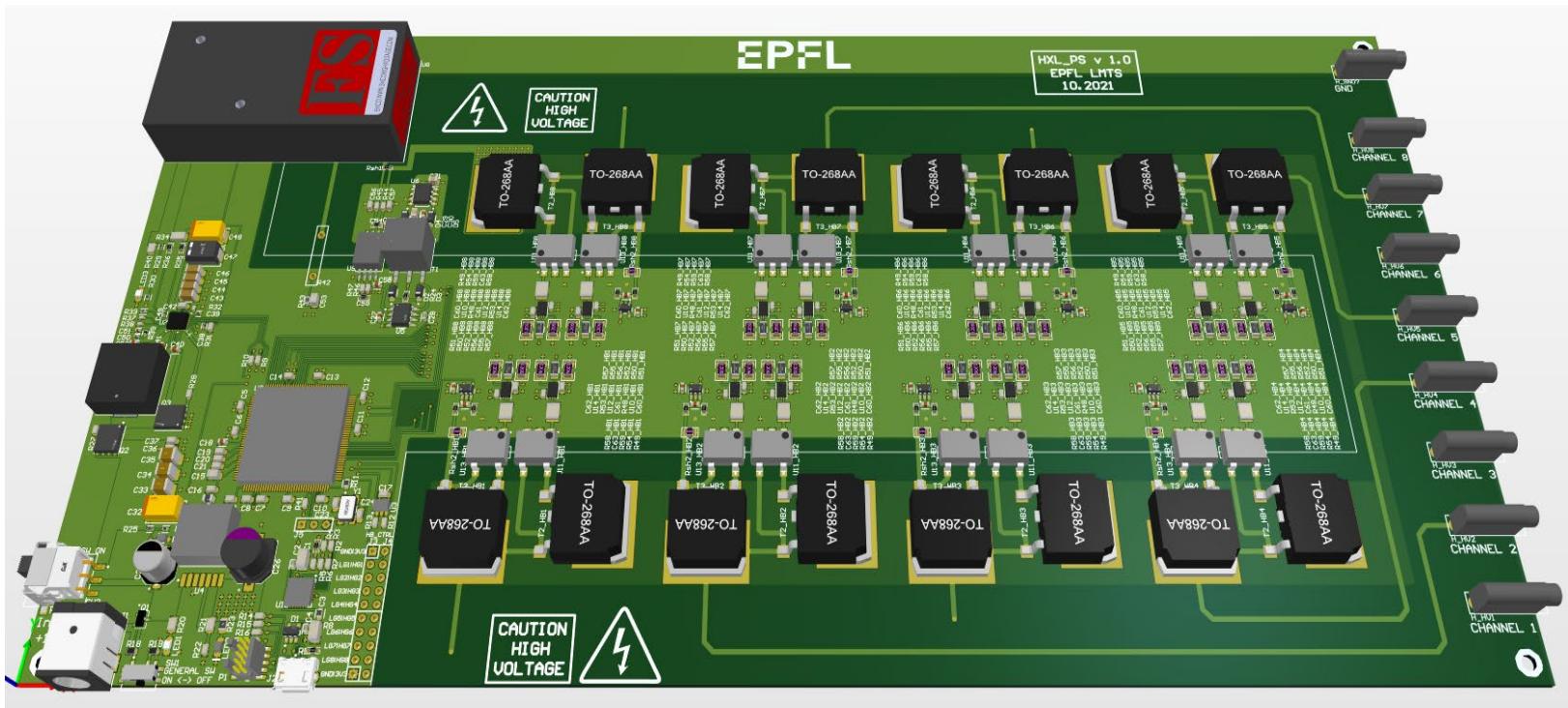
Hardware – Low-Side Current Measurement (HB_CM)

- Implemented solution: [INA180B4](#)
 - Current sense amplifier
 - Supply Voltage: 5V on high-side / 3.3V on low-side
 - Fixed gain: 200
 - Gain error: $\pm 1\%$
 - Single-Ended output
 - Maximal current expected: 5mA,
 - Maximal voltage given by the amplifier: 3.01V
- Specifications for the ADC used inside the microcontroller:
 - Resolution: 12-bits ($1 \mu\text{A}/\text{bit}$)
 - Sampling rate: 20 Ksps

Hardware – Low-Side Current Measurement (HB_CM)

- Block diagram:

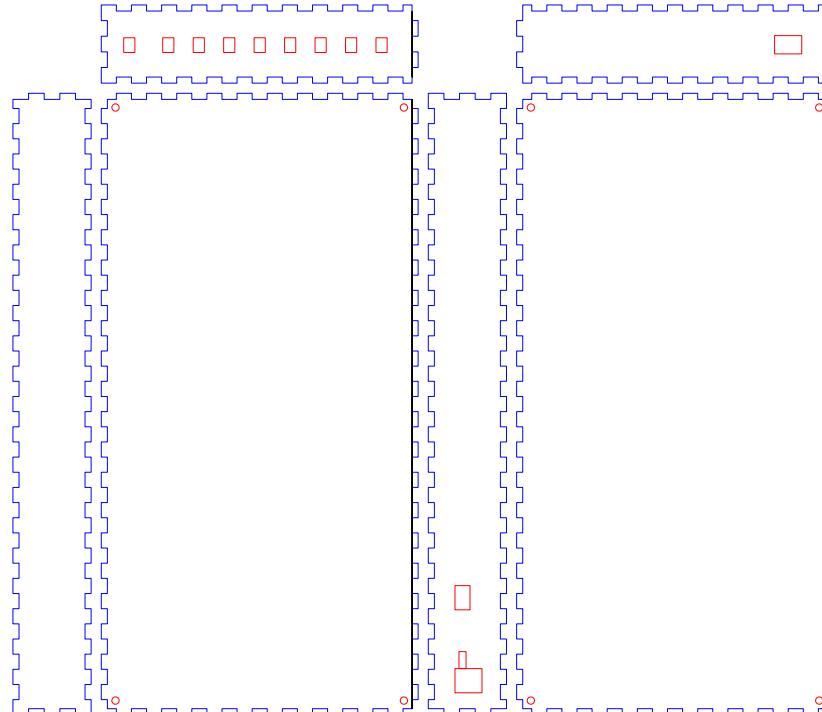




Total PCB size:
150 x 300 mm

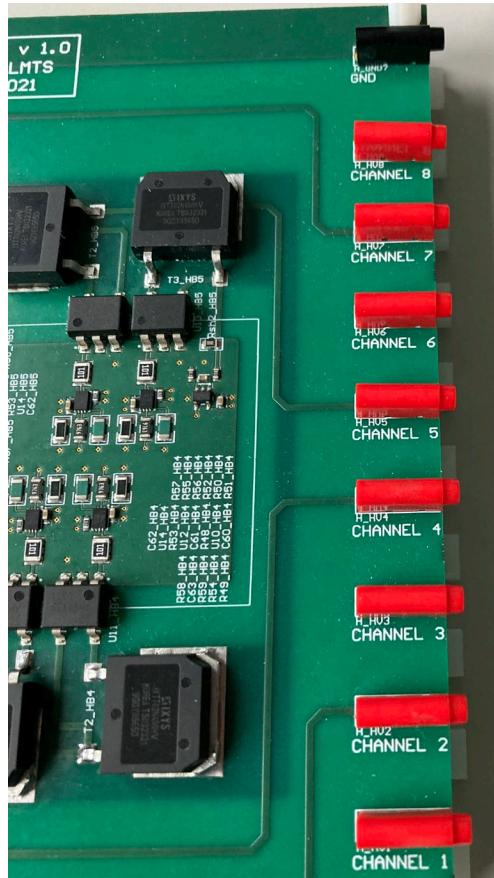
Hardware - Enclosure

- An .svg file can be found in the "2_HW" folder. It contains the plans for an enclosure made from 3-millimeter-thick PMMA sheets.
- You can use [InkScape](#) or another software to use it.



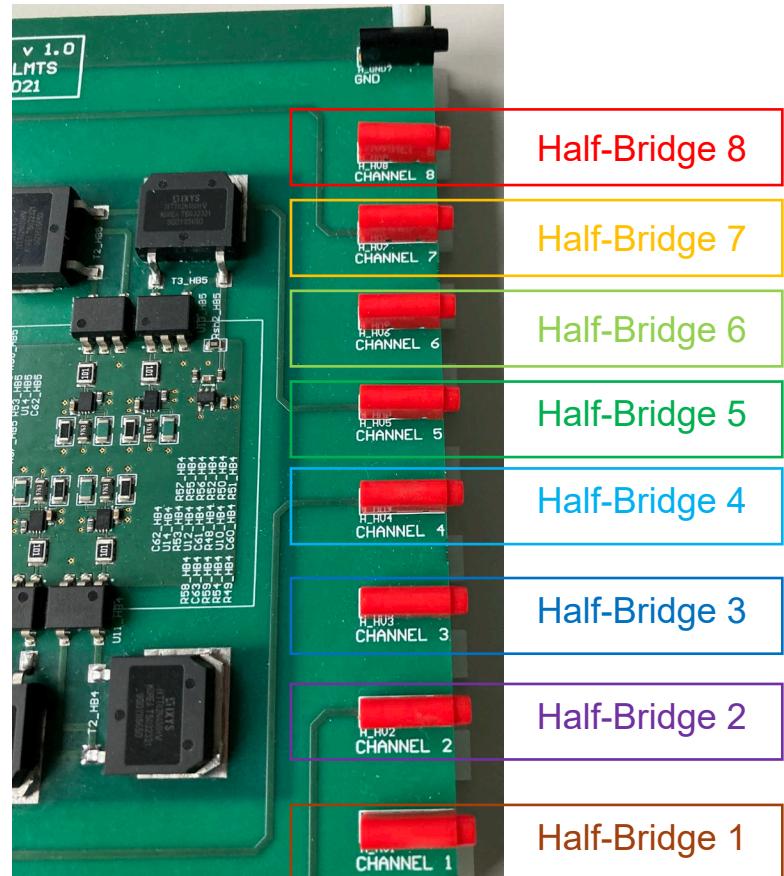
Firmware - Modes

- 8x channels
- 4 different modes



Firmware - Modes

- 8x channels
- 4 different modes
- Can be used in DC or unipolar:
 - 8x channels => 8 Half-Bridges
 - Half-Bridge 1 = Channel 1
 - Mode 1 & Mode 3



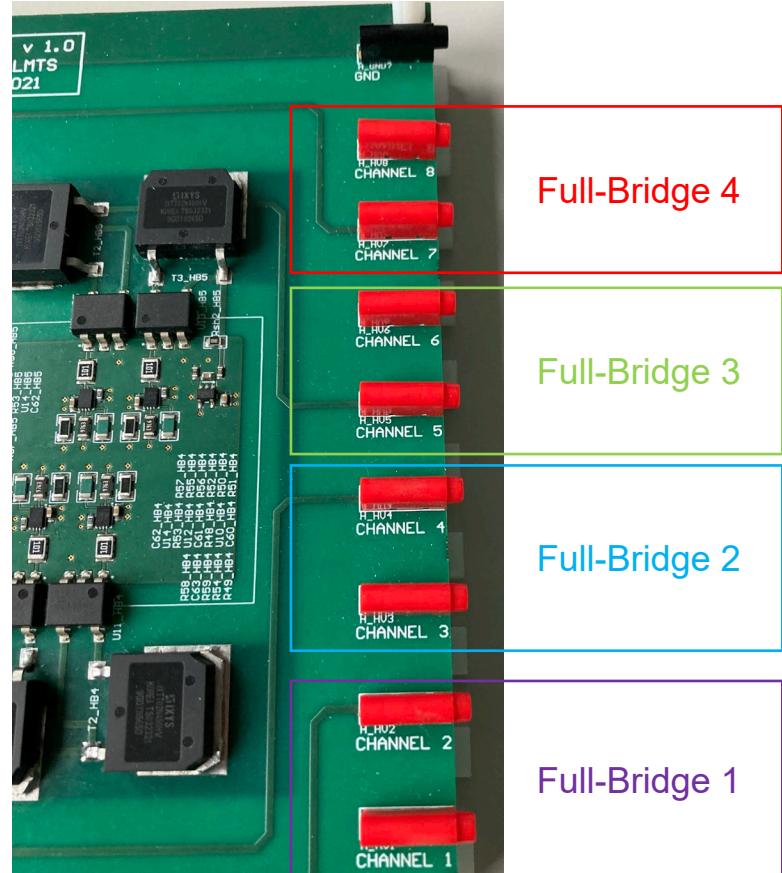
Firmware - Modes

- 8x channels
- 4 different modes
- Can be used in DC or unipolar:
 - 8x channels => 8 Half-Bridges
 - Half-Bridge 1 = Channel 1

➤ Mode 1 & Mode 3

- Can be used in bipolar:
 - 8x channels => 4x Full-Bridges
 - Full-Bridge 1 = Channel 1 + Channel 2

➤ Mode 2 & Mode 4



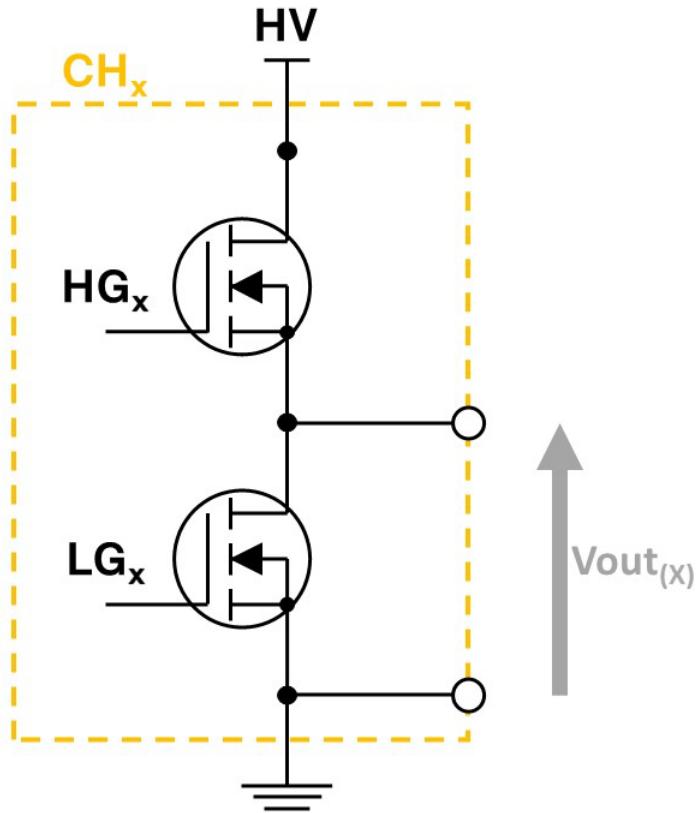
Full-Bridge 4

Full-Bridge 3

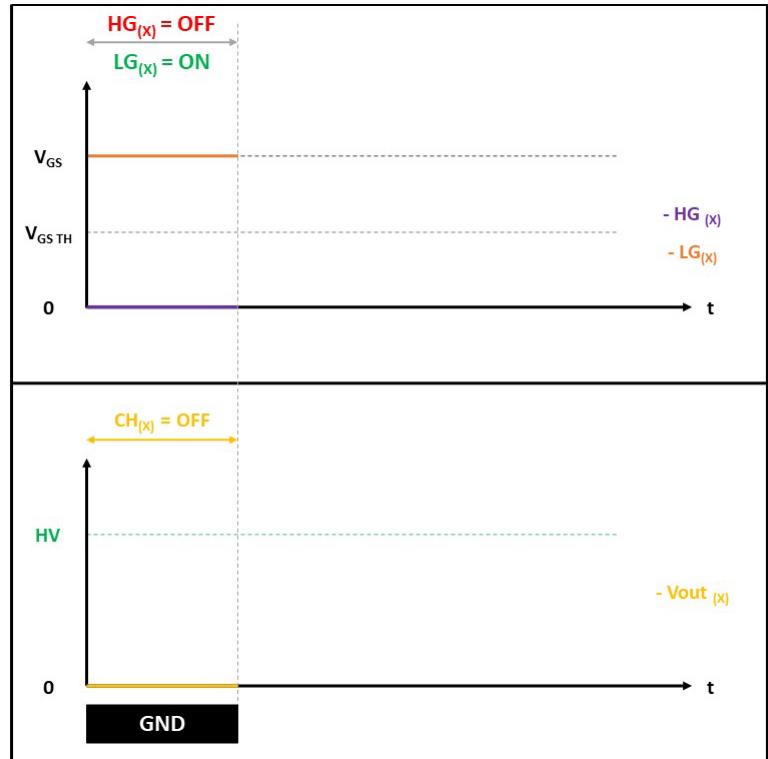
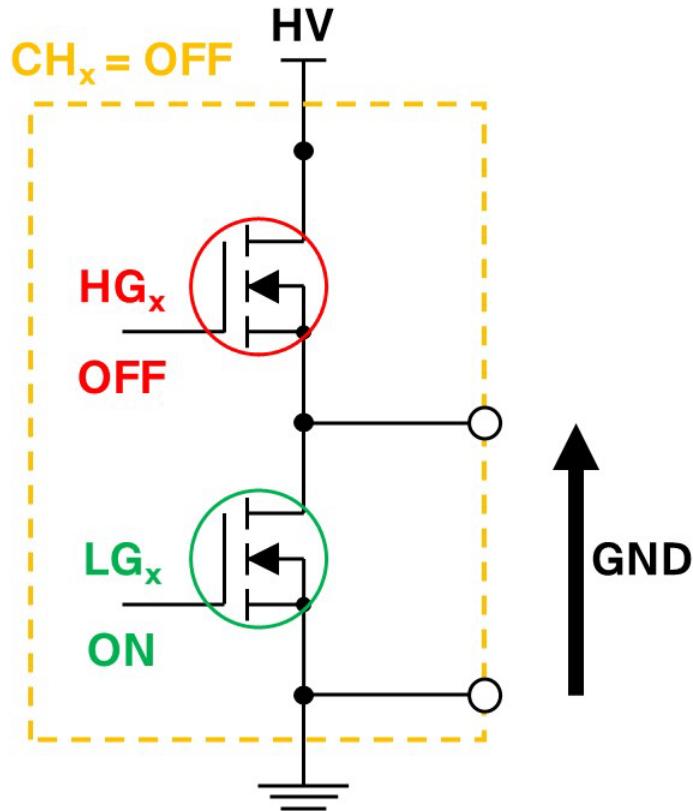
Full-Bridge 2

Full-Bridge 1

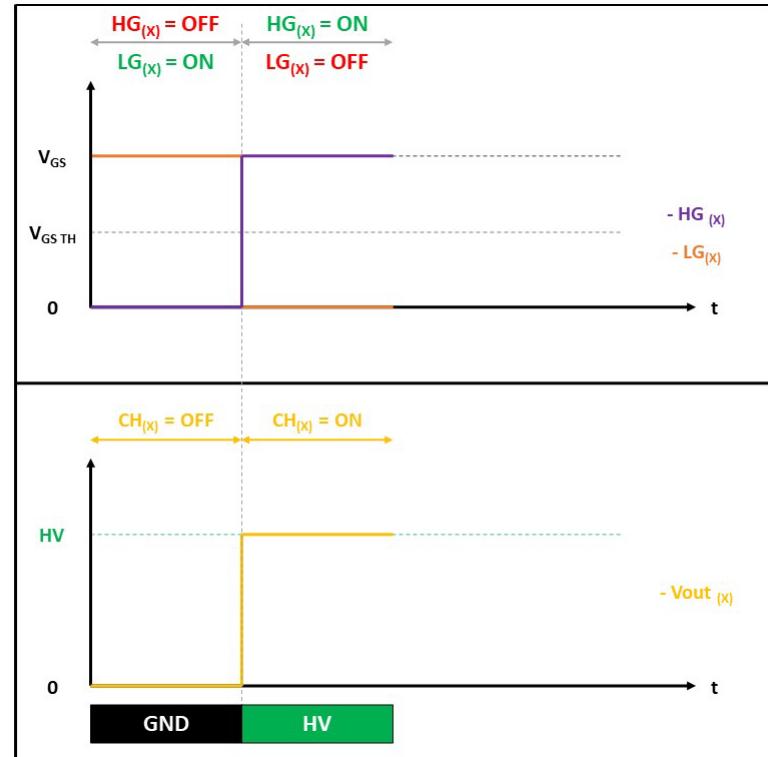
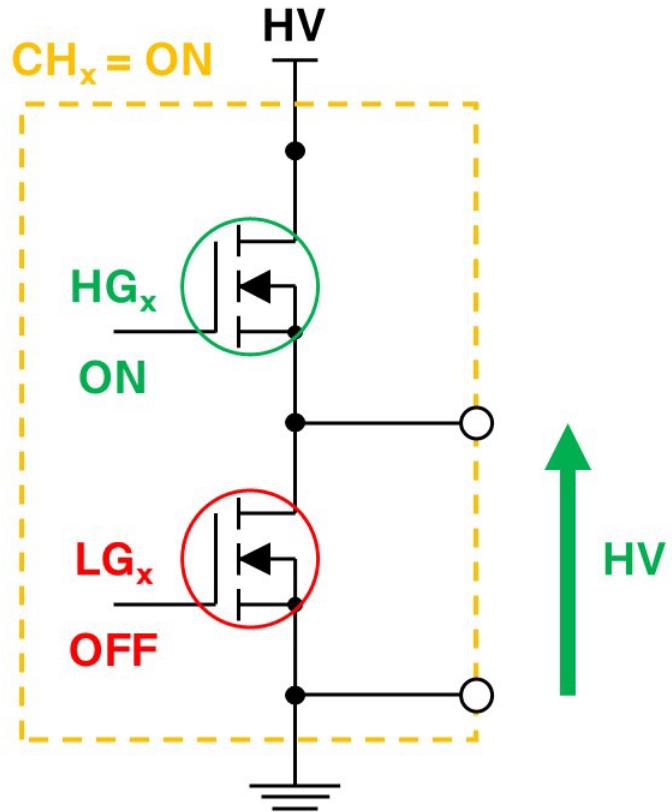
- Using a half-bridge:
 - To continuous power supply (DC)
 - To switch between OV and HV (unipolar)
 - States:
 - OFF: Output of selected half-bridge is connected to the ground
 - ON: Output of selected half-bridge is switching between +HV and the ground
 - Parameters:
 - Frequency: Switching frequency (Hz)
 - PosDuty: Positive Duty Cycle (%) (= Positive Pulse Width / Period)



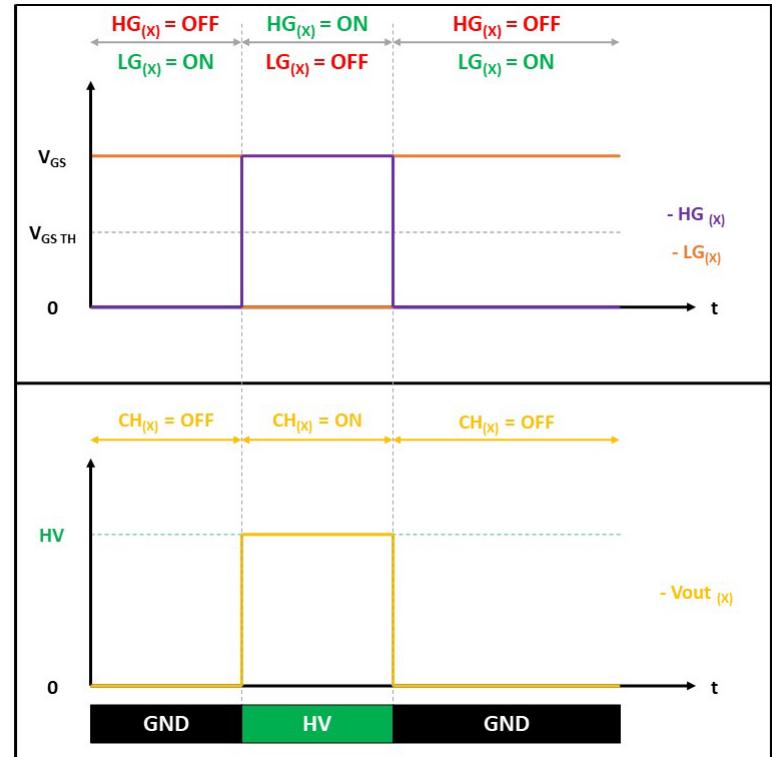
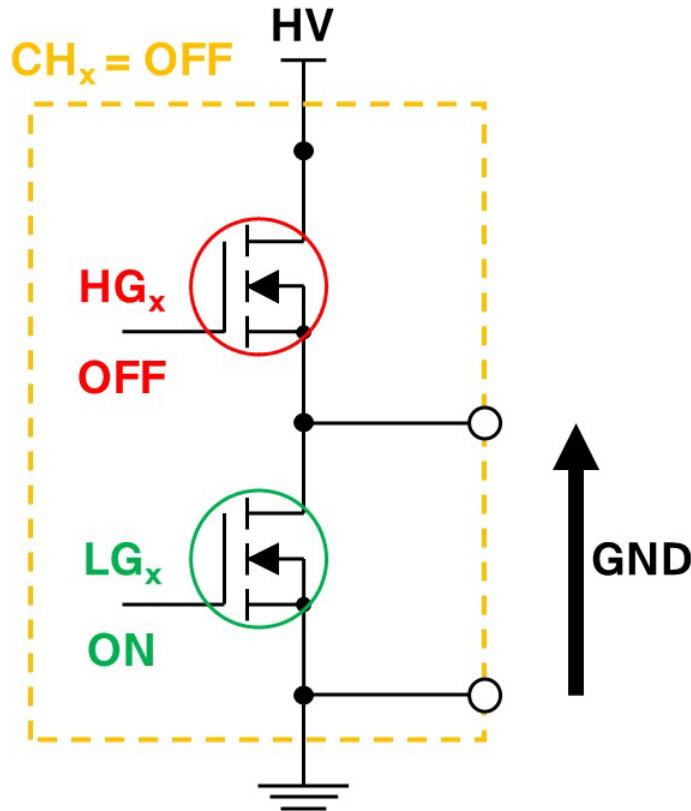
Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)



Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)

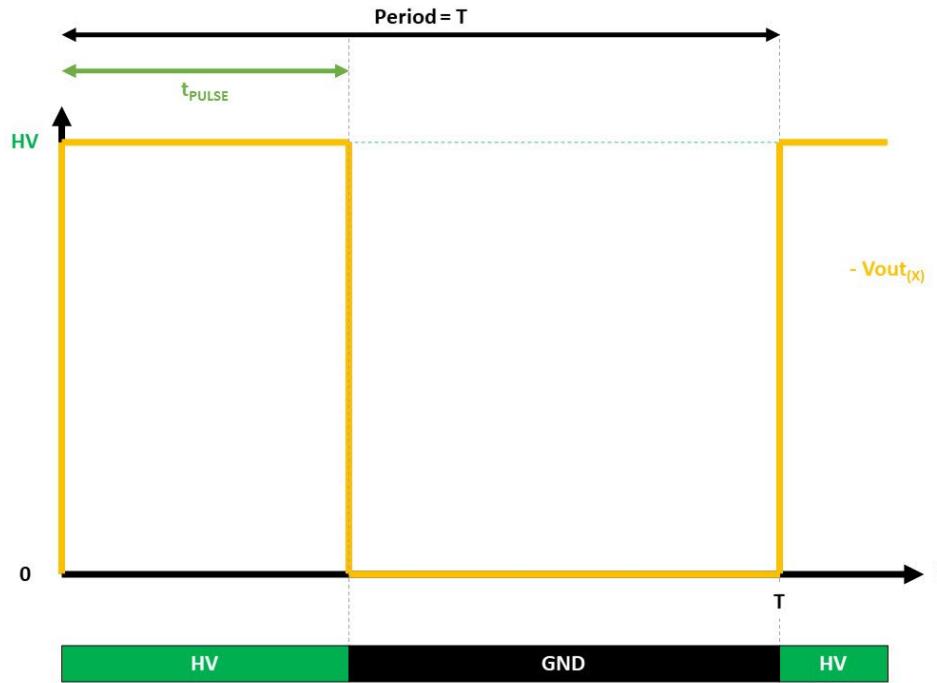


Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)



Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)

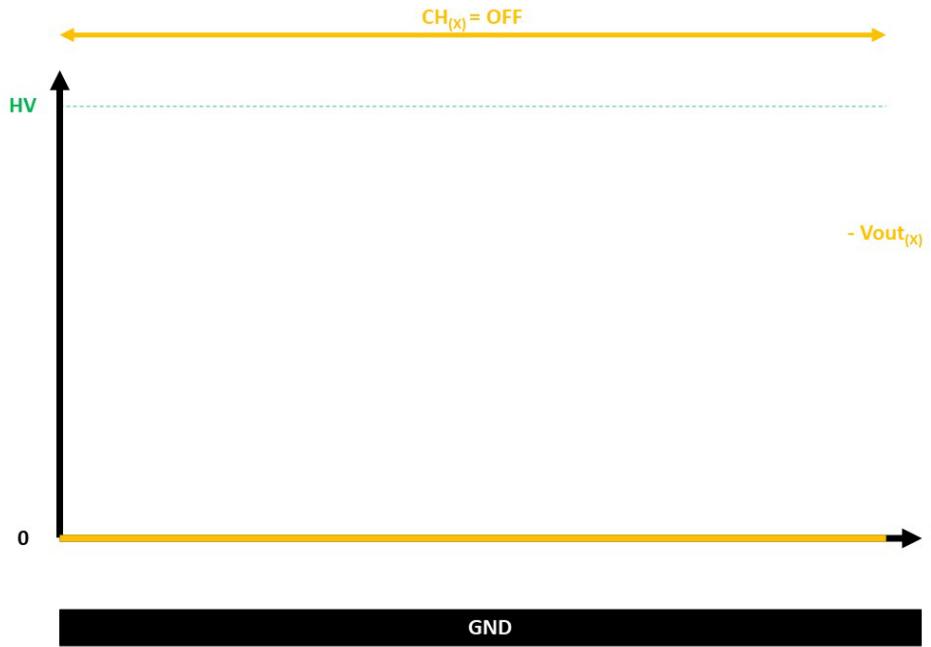
- Example:



Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)

- Example:

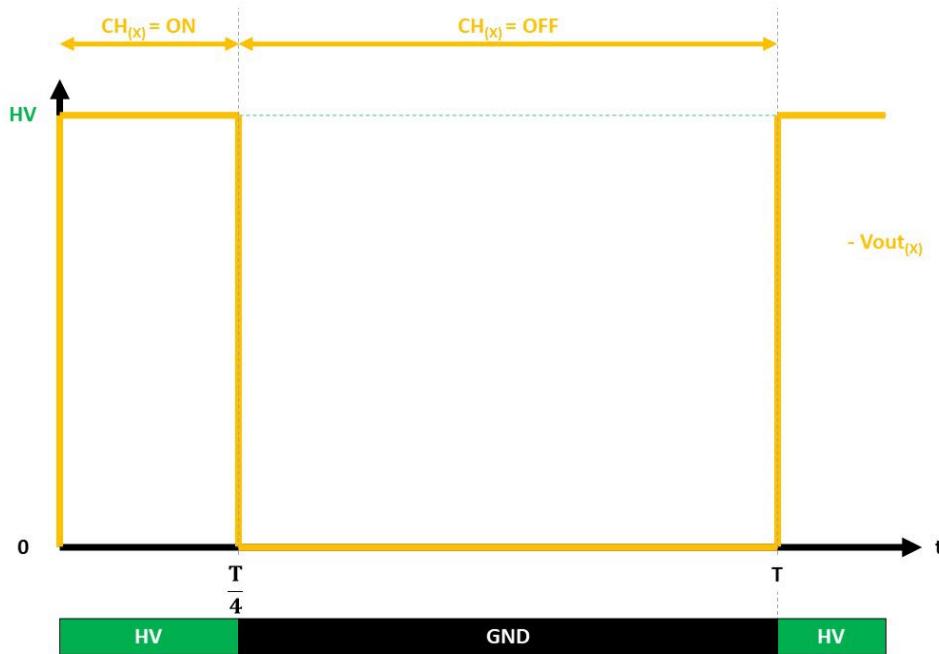
- CHx OFF
- Frequency: - Hz
- PosDuty: - %



Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)

- Example:

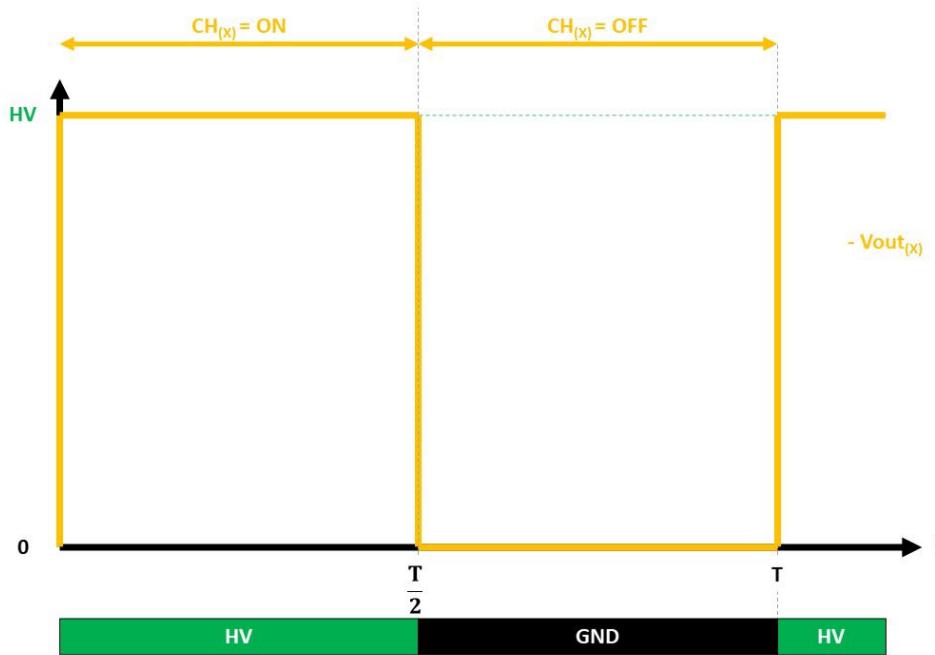
- CHx **ON**
- Frequency: $x \text{ Hz}$
- PosDuty: 25 %



Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)

- Example:

- CHx **ON**
- Frequency: **x Hz**
- PosDuty: **50 %**



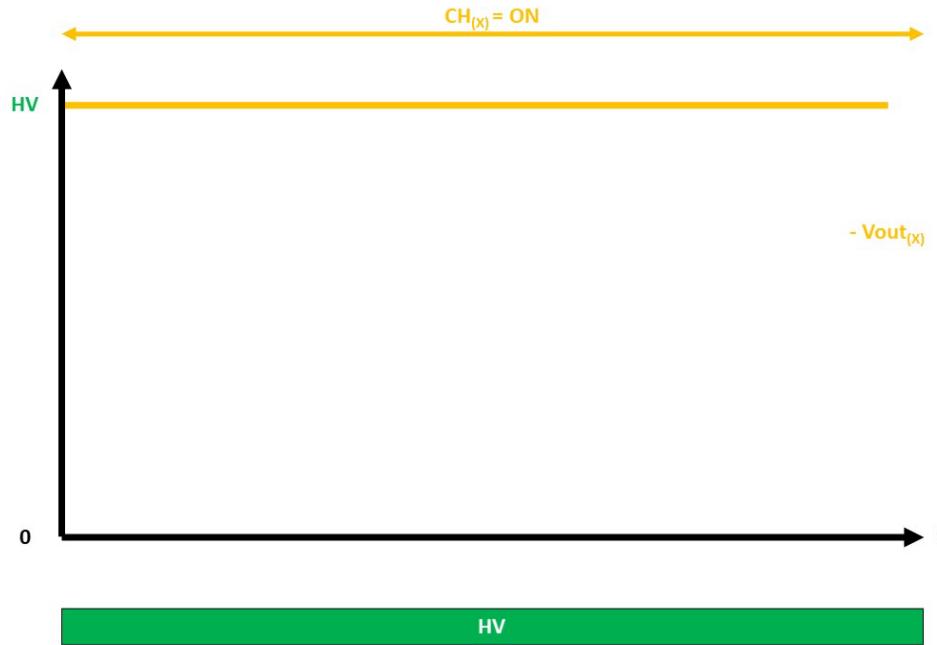
Firmware – Mode 1: DC or unipolar switching (Half-Bridge operation)

- Example:

- CHx ON
- Frequency: 0 Hz
- PosDuty: x %

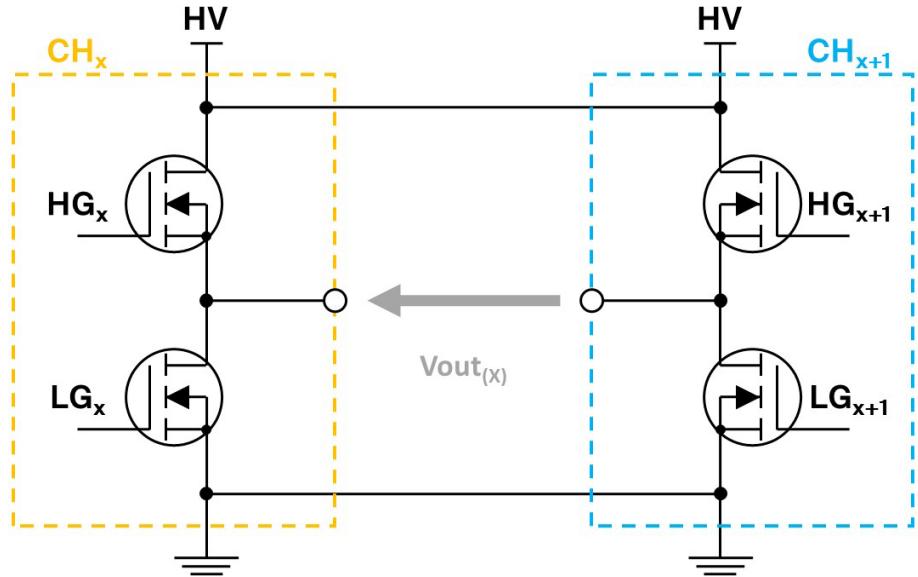
OR

- CHx ON
- Frequency: x Hz
- PosDuty: 100%

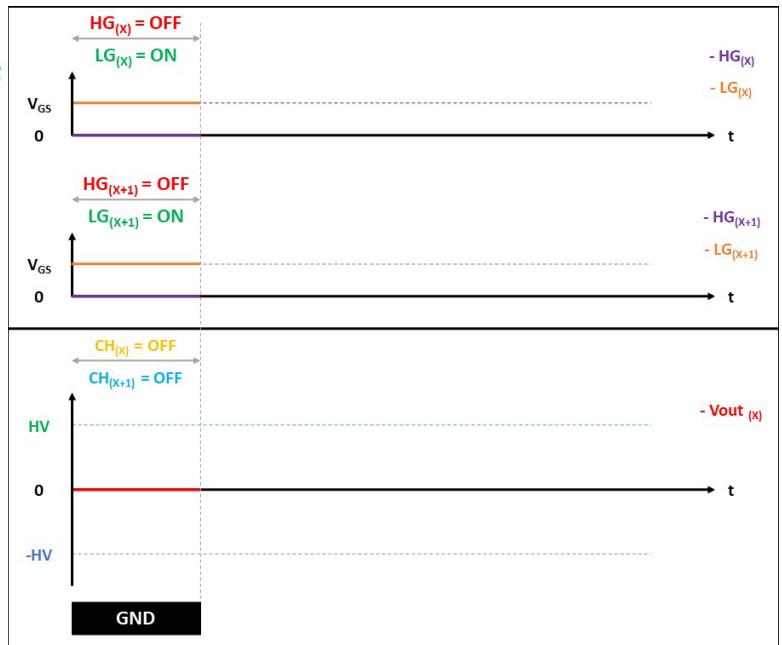
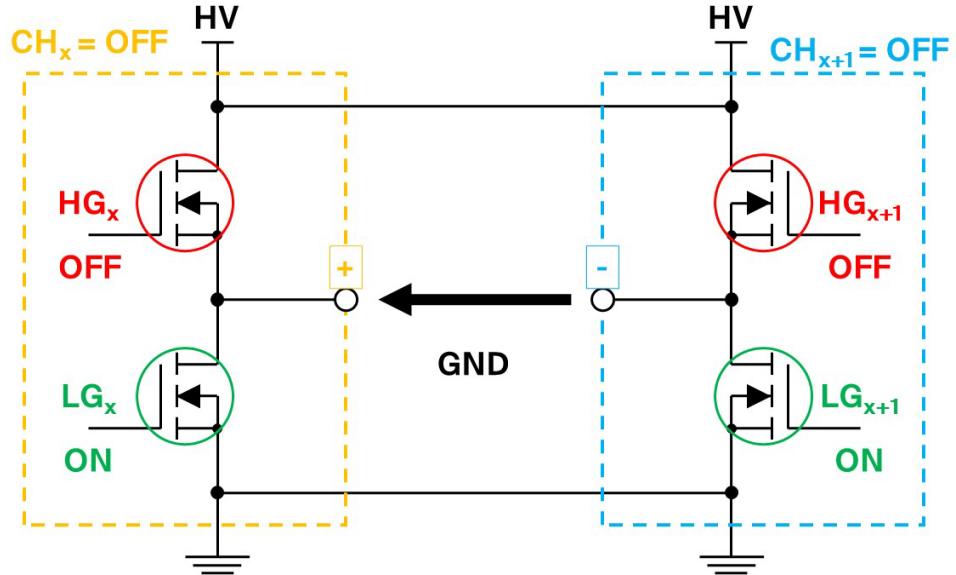


Firmware – Mode 2: Bipolar switching (Full-Bridge operation)

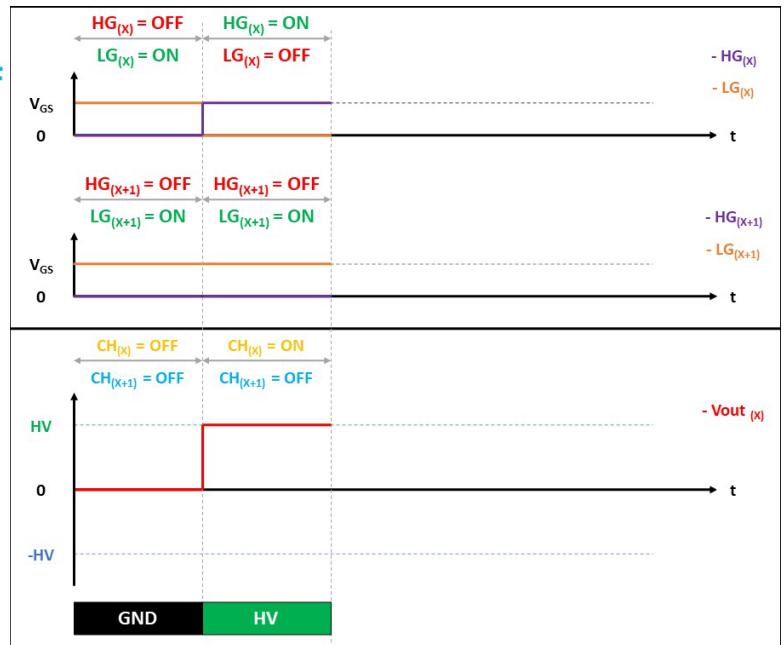
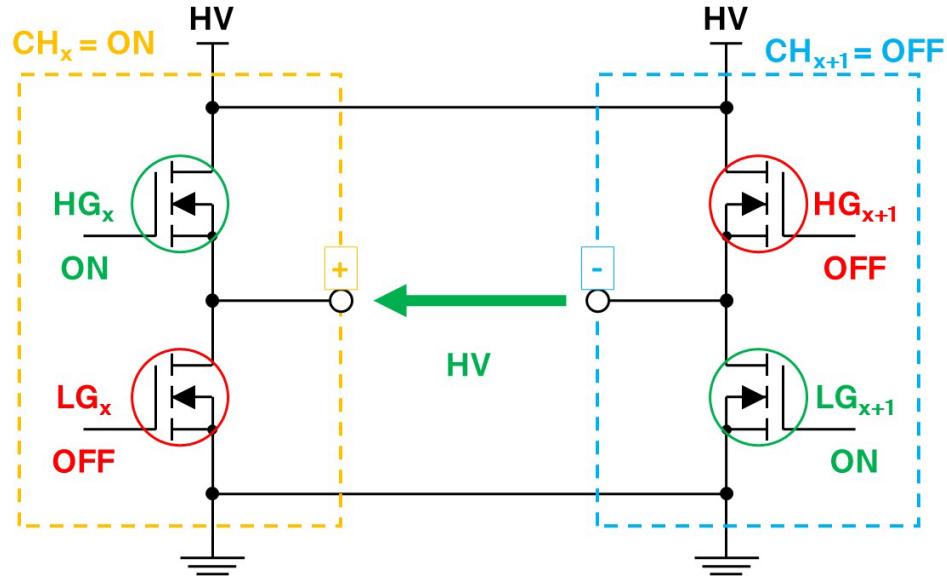
- Using a full-bridge (by combining two half-bridges) to switch between -HV and +HV (bipolar)
- States:
 - OFF: Output of selected full-bridge is connected to the ground
 - ON: Output of selected full-bridge is switching between +HV and -HV
- Parameters:
 - Frequency: Switching frequency (Hz)
 - PosDuty: Positive Duty Cycle (%) (= Positive Pulse Width / Period)
 - NegDuty: Negative Duty Cycle (%) (= Negative Pulse Width / Period)
 - Pulse phase: Phase (°) between positive and negative pulses



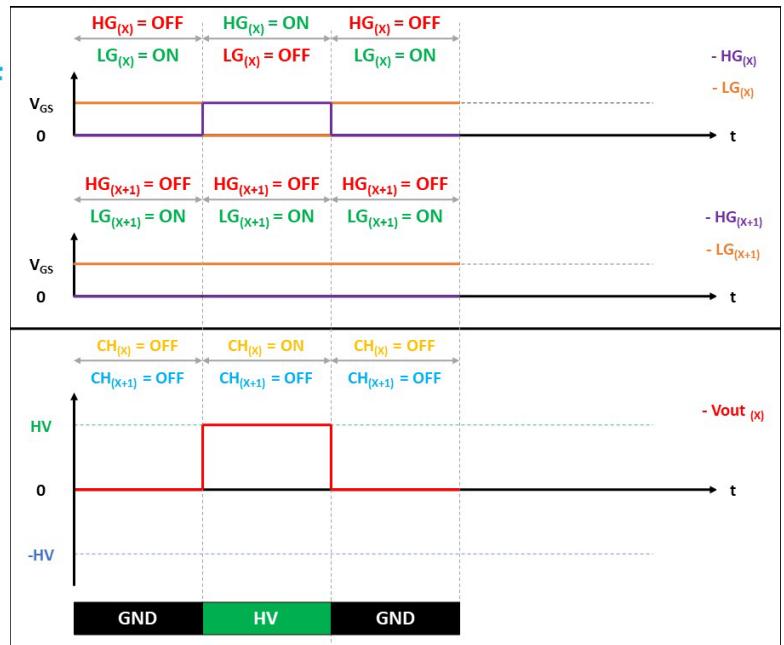
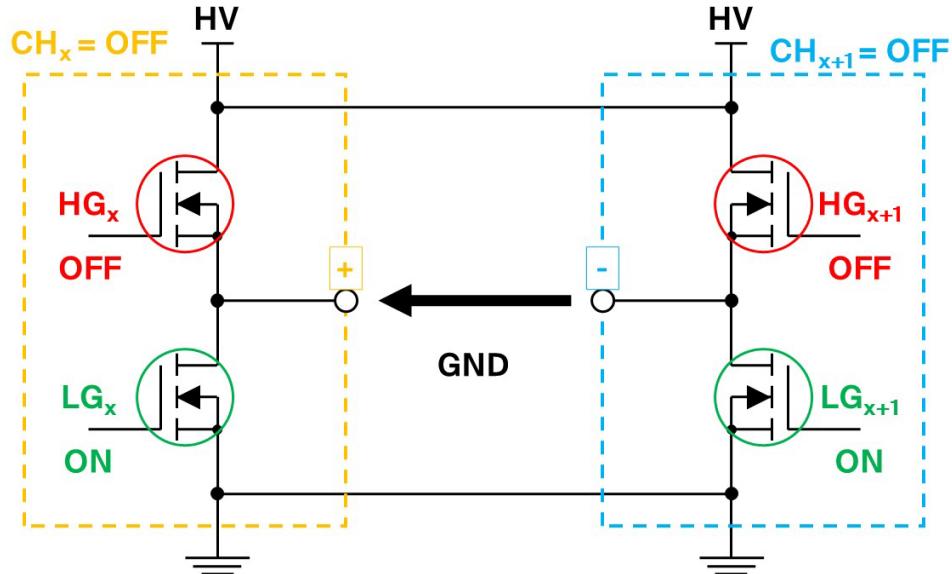
Firmware – Mode 2: Bipolar switching (Full-Bridge operation)



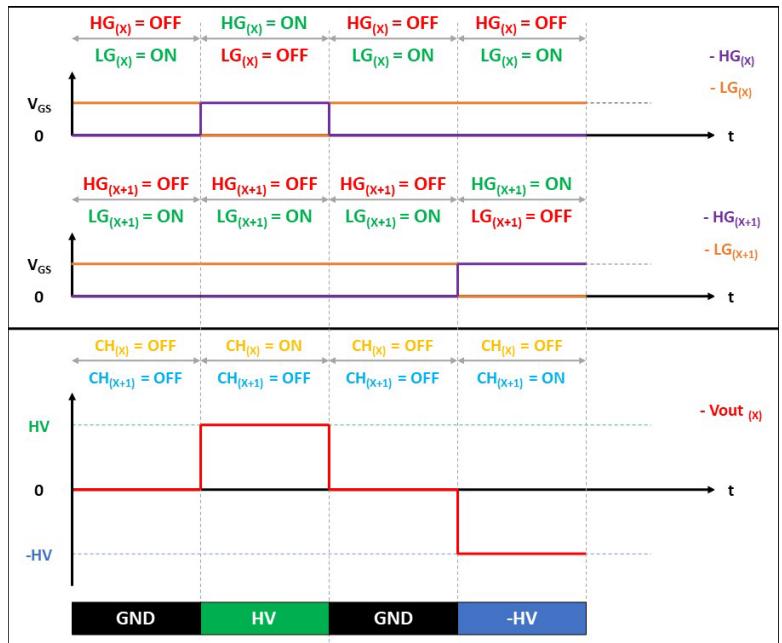
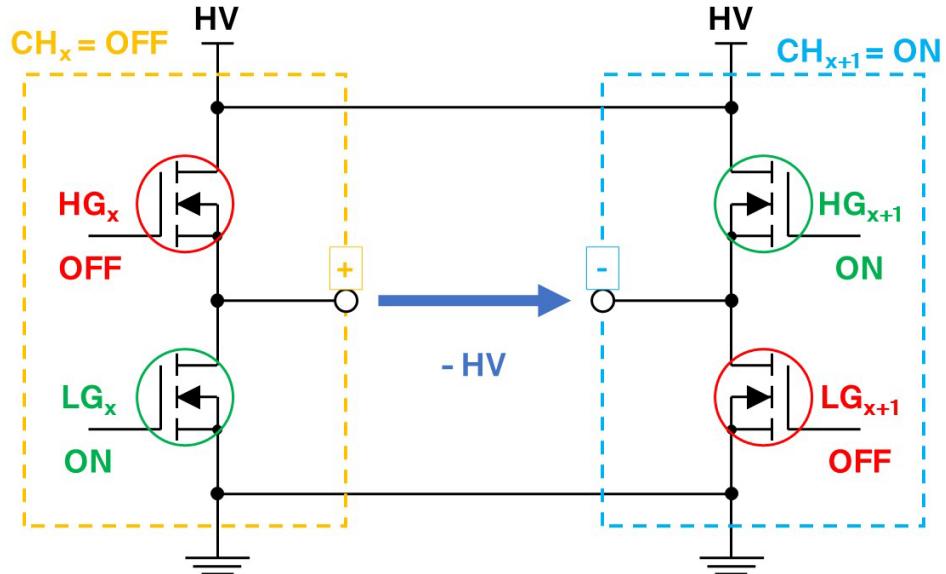
Firmware – Mode 2: Bipolar switching (Full-Bridge operation)



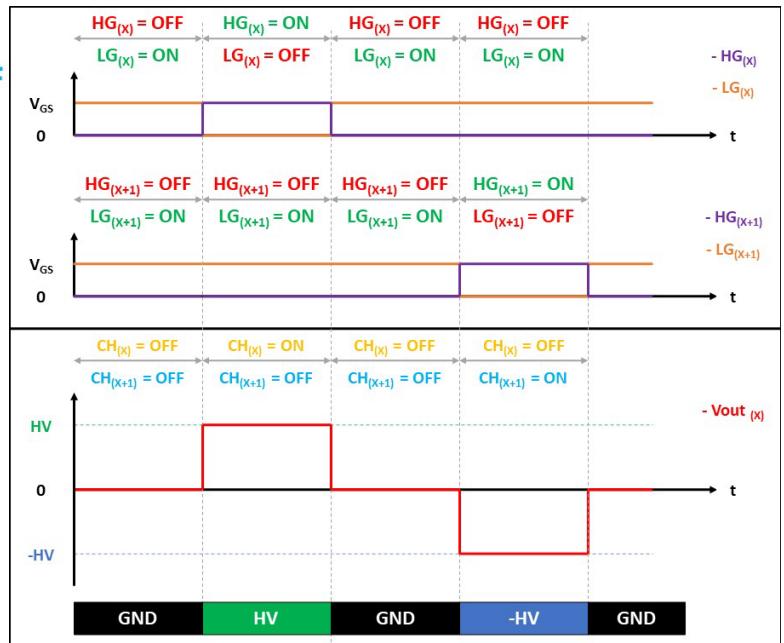
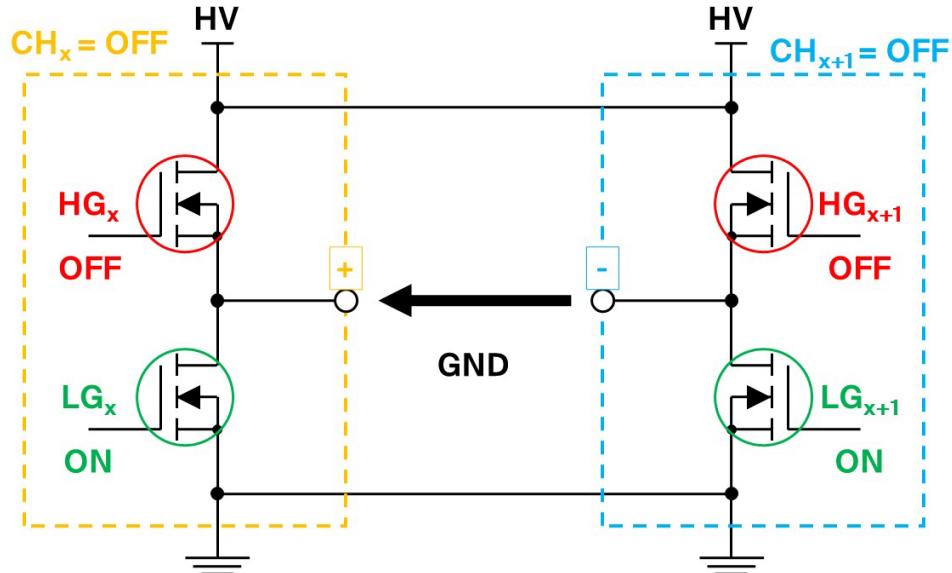
Firmware – Mode 2: Bipolar switching (Full-Bridge operation)



Firmware – Mode 2: Bipolar switching (Full-Bridge operation)

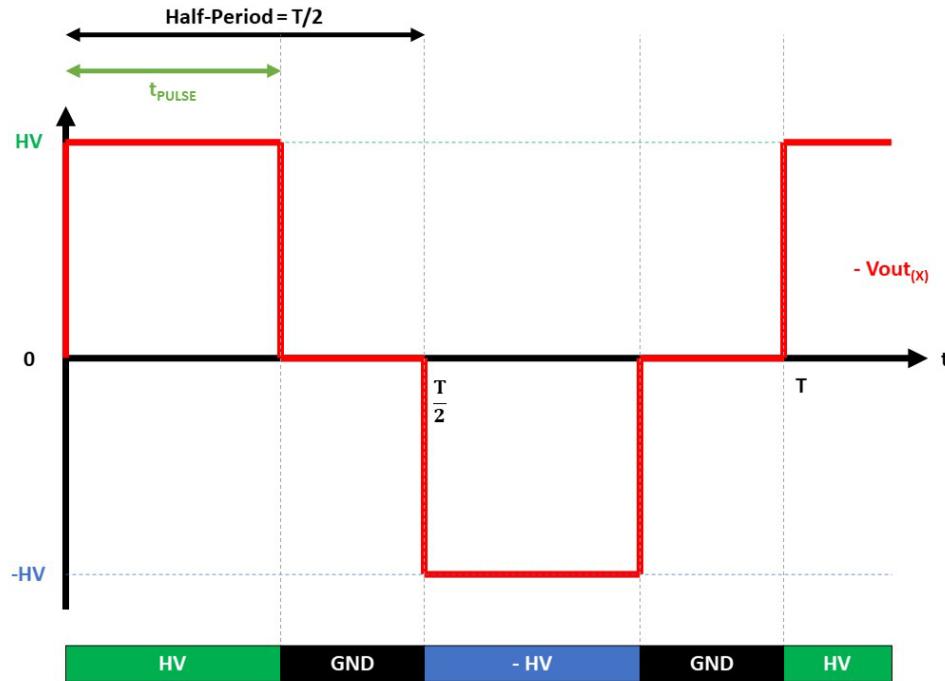


Firmware – Mode 2: Bipolar switching (Full-Bridge operation)



Firmware – Mode 2: Bipolar switching (Full-Bridge operation)

- Example:



Firmware – Mode 2: Bipolar switching (Full-Bridge operation)

- Example:

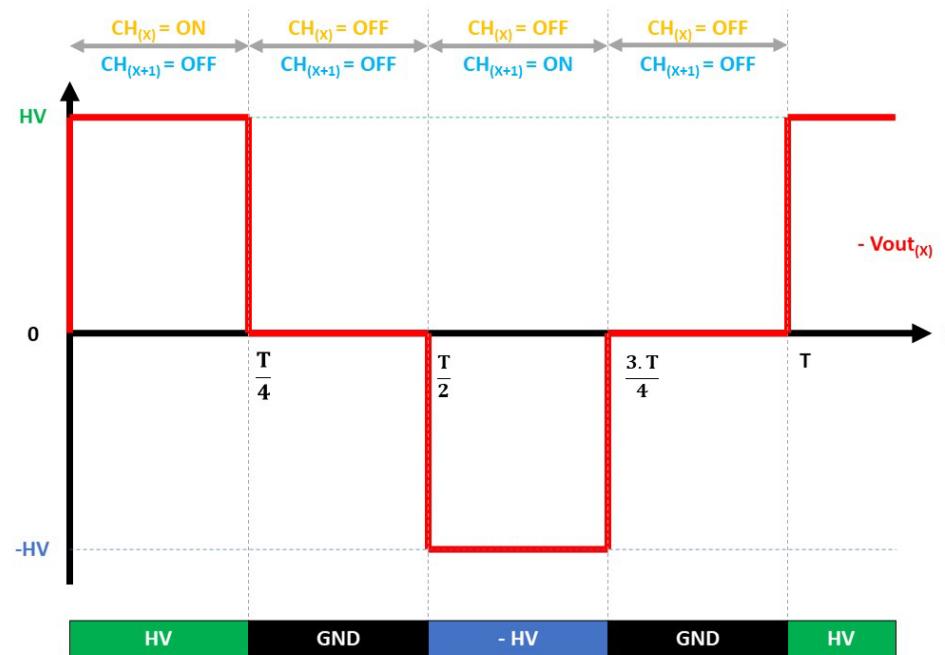
- FBx OFF
- Frequency: - Hz
- PosDuty: - %
- NegDuty: - %
- Phase Pulse - °



Firmware – Mode 2: Bipolar switching (Full-Bridge operation)

- Example:

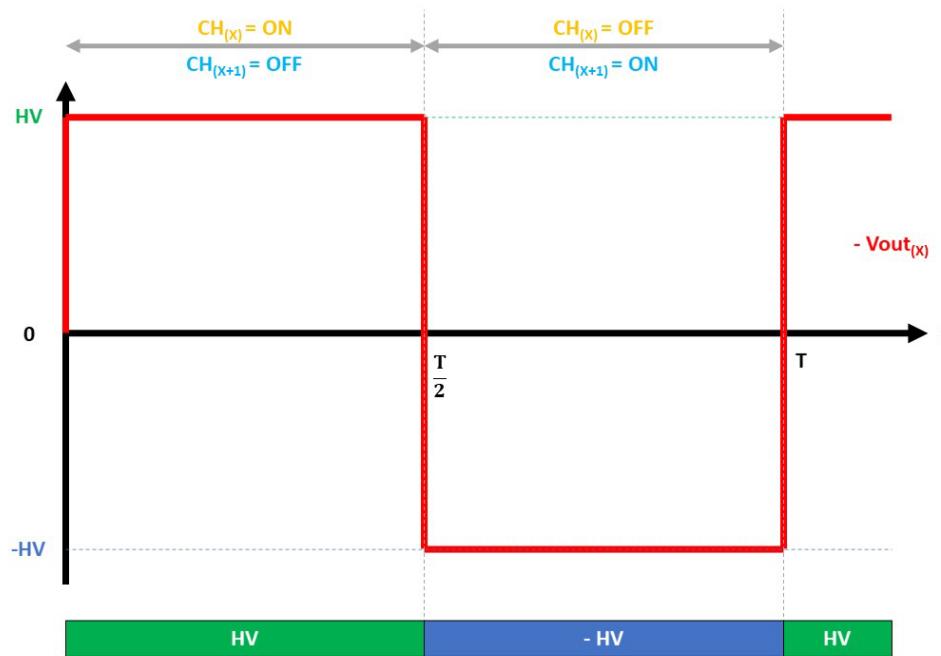
- FBx ON
- Frequency: x Hz
- PosDuty: 25 %
- NegDuty: 25 %
- Phase Pulse 180°



Firmware – Mode 2: Bipolar switching (Full-Bridge operation)

- Example:

- FBx **ON**
- Frequency: **x Hz**
- PosDuty: **50 %**
- NegDuty: **50 %**
- Phase Pulse **180°**



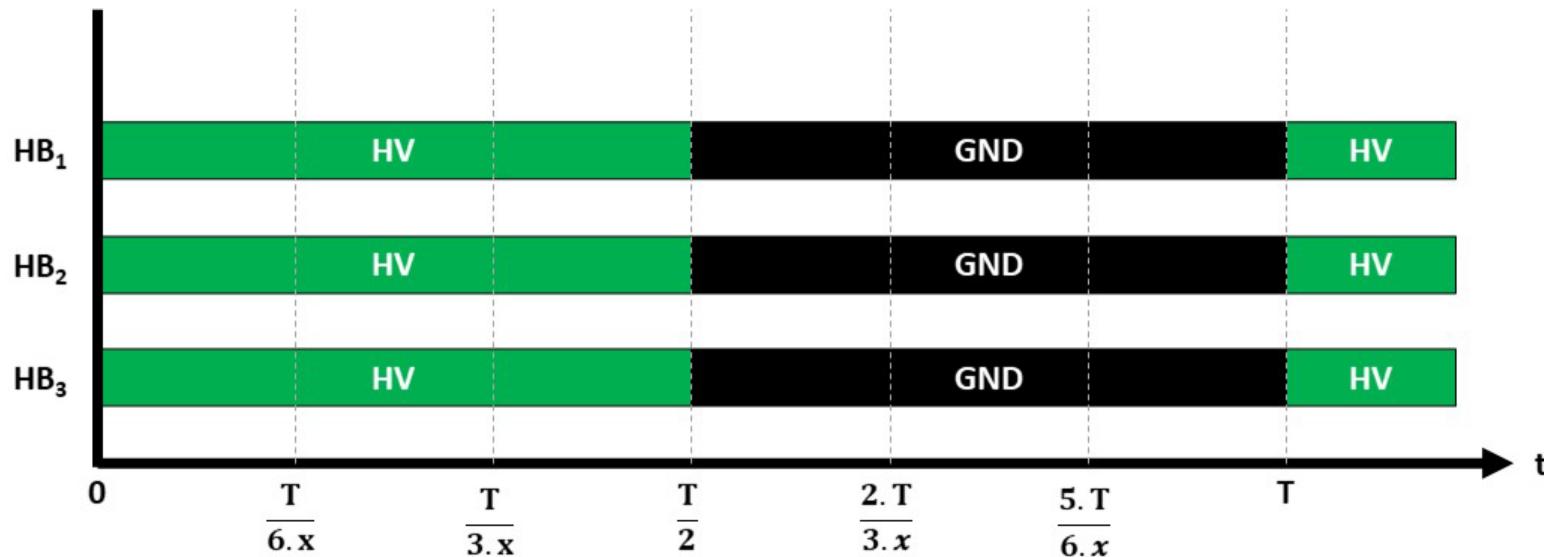
Firmware – Mode 3: DC or unipolar switching for multiples channels

- Using one or multiple half-bridges:
 - To continuous power supply (DC)
 - To switch between 0V and HV (unipolar), with or without phase between two channels
- Same that Mode 1 except user can start multiple channels in simultaneous, or with a phase between two channels
- States:
 - OFF: Output of selected half-bridge is connected to the ground
 - ON: Output of selected half-bridge is switching between +HV and the ground
- Parameters:
 - Number of channel: 1 to 8
 - Frequency: Switching frequency (Hz)
 - PosDuty: Positive Duty Cycle (%) (= Positive Pulse Width / Period)
 - Phase shift: Phase (°) between two channels

Firmware – Mode 3: DC or unipolar switching for multiples channels

- Example:

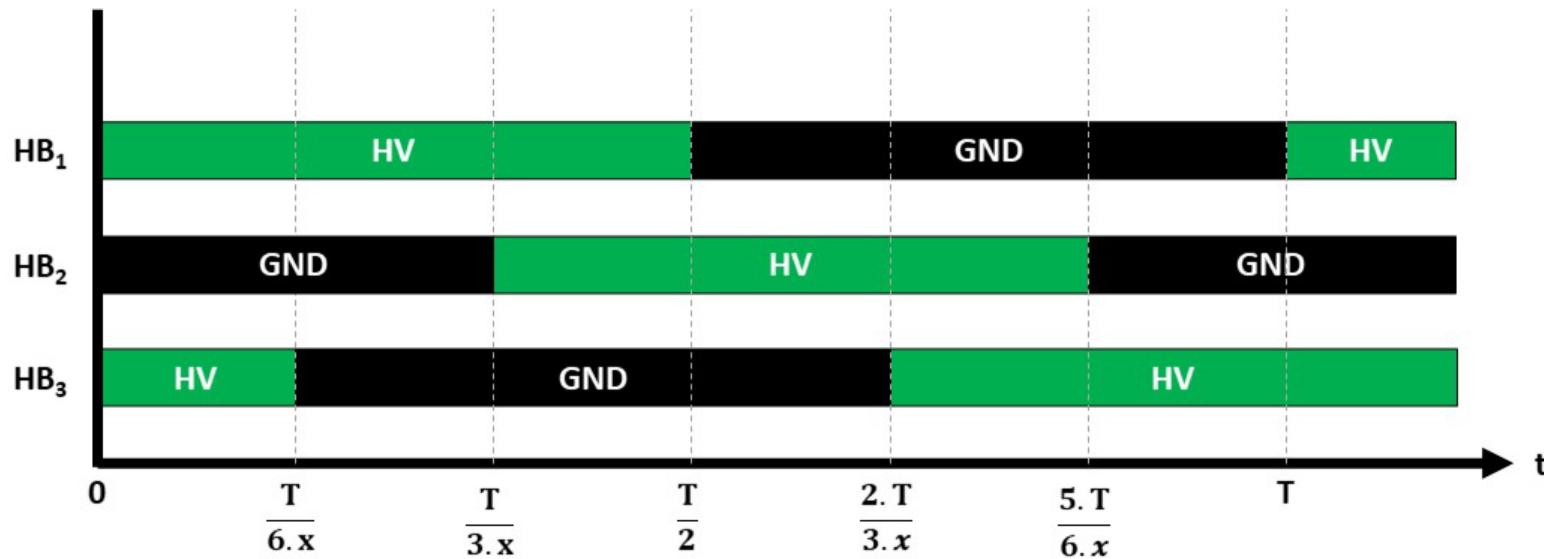
- Nb. of channels: 3
- Frequency: x Hz
- PosDuty: 50 %
- Pulse phase: 0 °



Firmware – Mode 3: DC or unipolar switching for multiples channels

- Example:

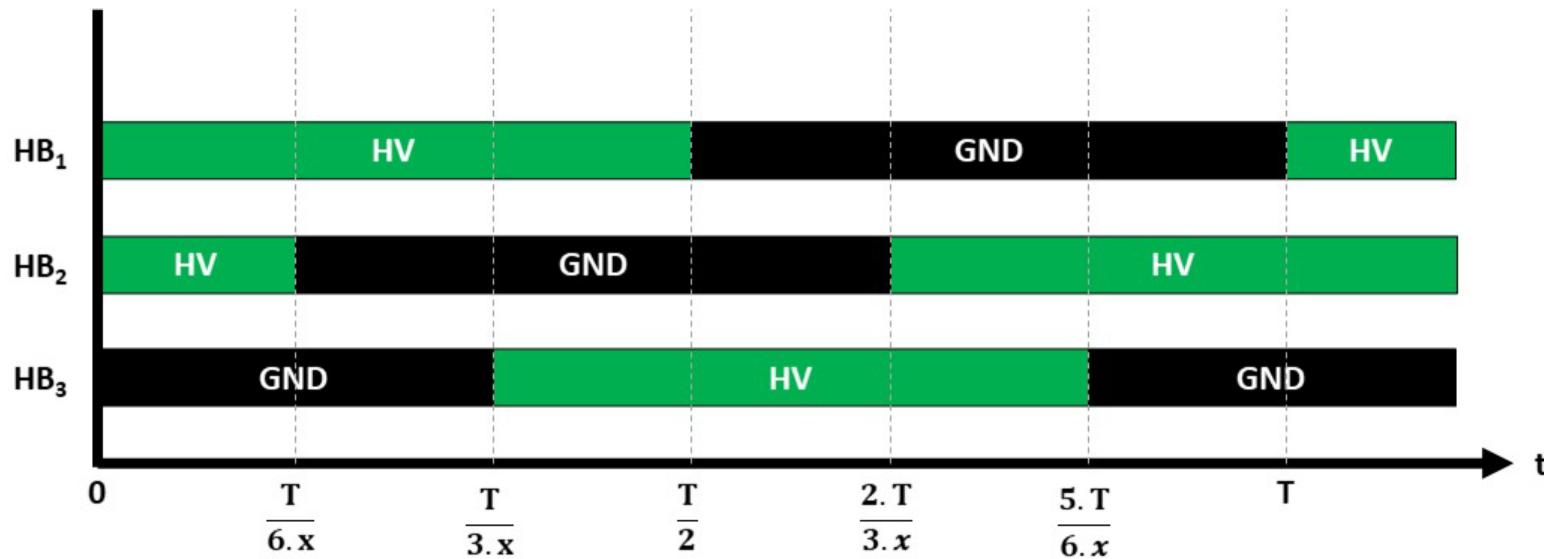
- Nb. of channels: 3
- Frequency: x Hz
- PosDuty: 50 %
- Pulse phase: 120 °



Firmware – Mode 3: DC or unipolar switching for multiples channels

- Example:

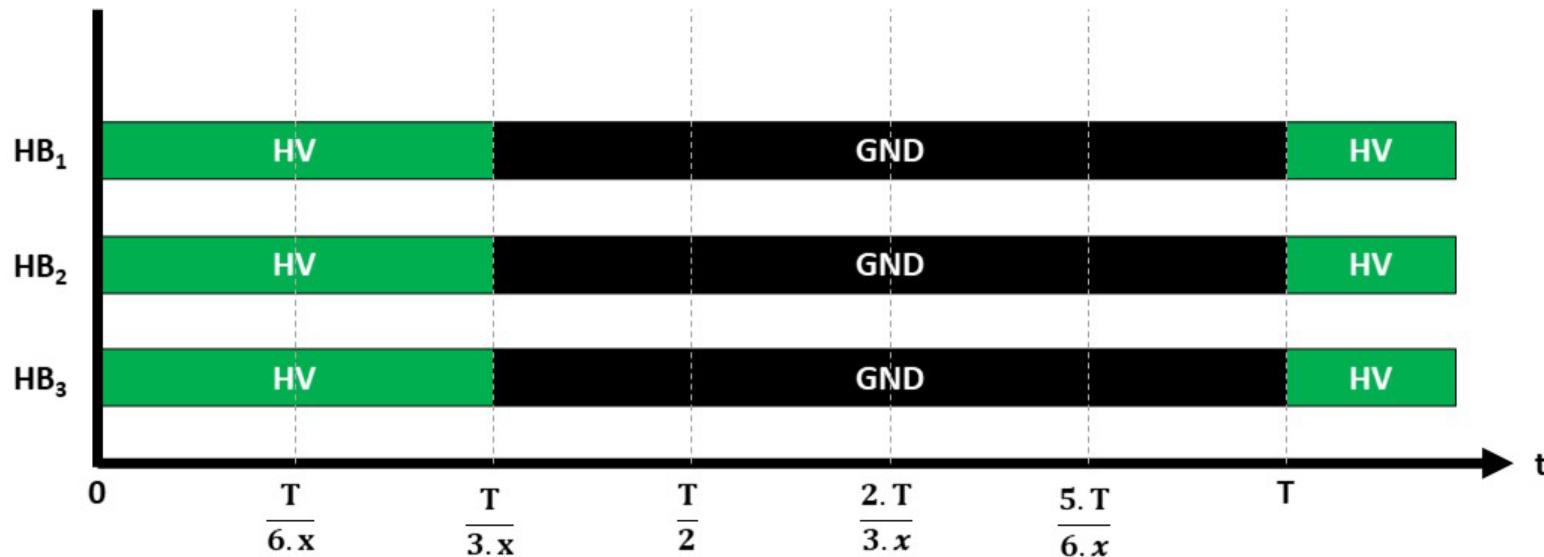
- Nb. of channels: 3
- Frequency: x Hz
- PosDuty: 50 %
- Pulse phase: 240 °



Firmware – Mode 3: DC or unipolar switching for multiples channels

- Example:

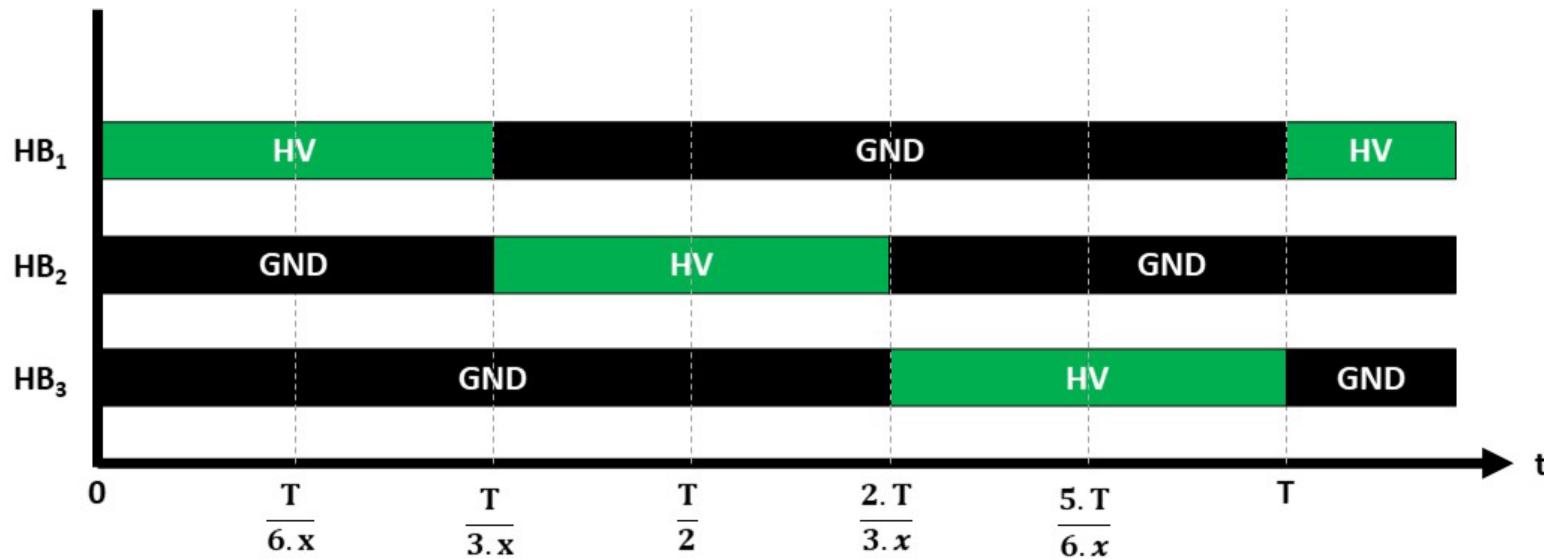
- Nb. of channels: 3
- Frequency: $x \text{ Hz}$
- PosDuty: 33.3 %
- Pulse phase: 0°



Firmware – Mode 3: DC or unipolar switching for multiples channels

- Example:

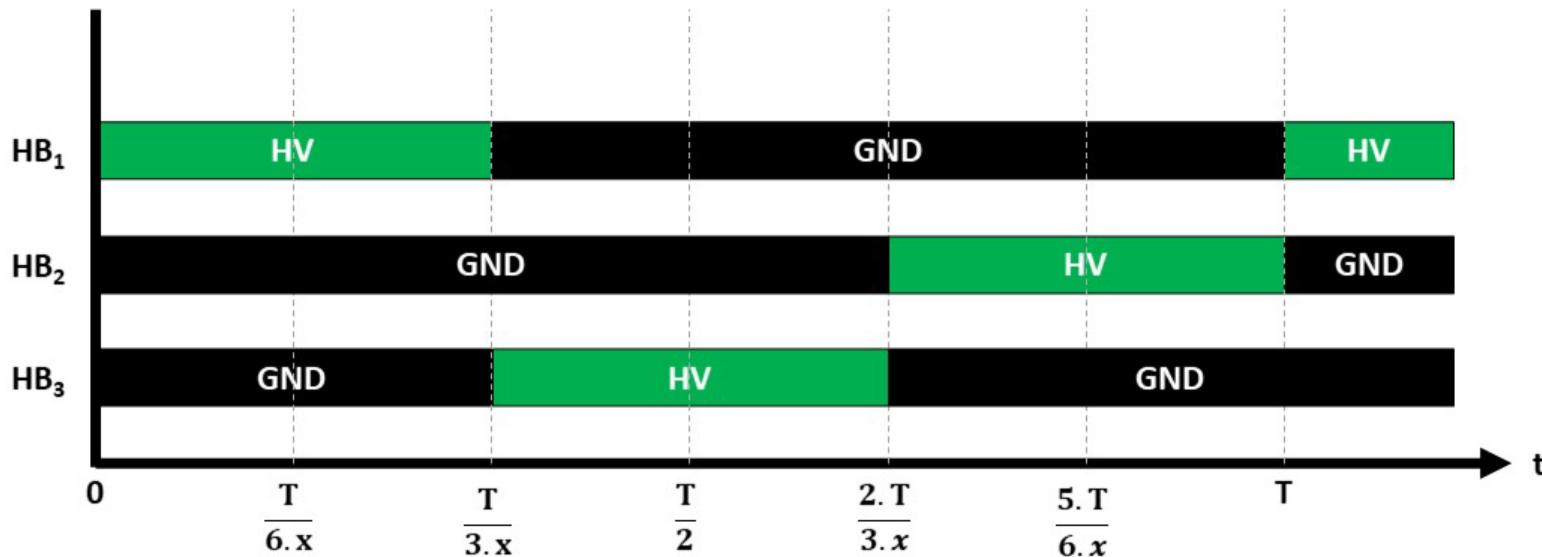
- Nb. of channels: 3
- Frequency: x Hz
- PosDuty: 33.3 %
- Pulse phase: 120 °



Firmware – Mode 3: DC or unipolar switching for multiples channels

- Example:

- Nb. of channels: 3
- Frequency: x Hz
- PosDuty: 33.3 %
- Pulse phase: 240 °



Firmware – Mode 4: Bipolar switching for multiples channels

- Using a full-bridge (by combining two half-bridges) to switch between -HV and +HV (bipolar). Same that Mode 2 except user can start multiple channels in simultaneous, or with a phase between two channels

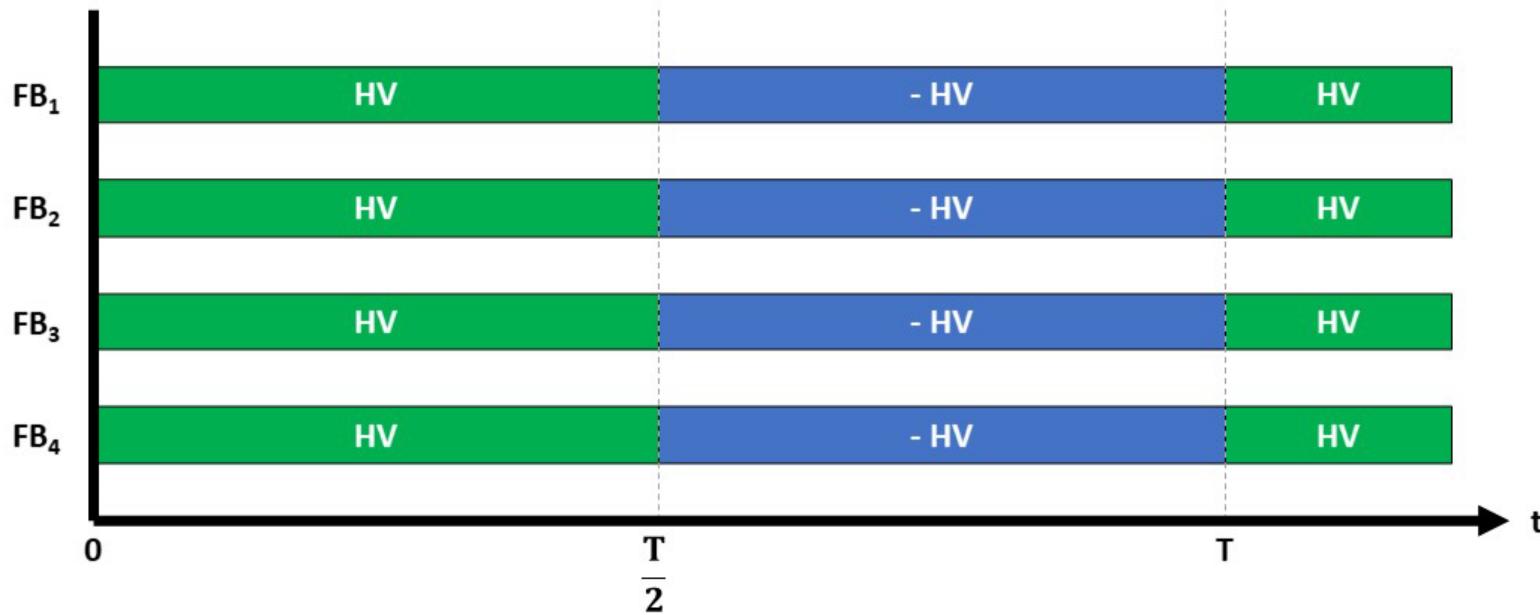
- States:
 - OFF: Output of selected full-bridge is connected to the ground
 - ON: Output of selected full-bridge is switching between +HV and -HV

- Parameters:
 - Number of channel: 1 to 4
 - Frequency: Switching frequency (Hz)
 - PosDuty: Positive Duty Cycle (%) (= Positive Pulse Width / Period)
 - NegDuty: Negative Duty Cycle (%) (= Negative Pulse Width / Period)
 - Pulse phase: Phase (°) between positive and negative pulses
 - Phase shift: Phase (°) between two channels

Firmware – Mode 4: Bipolar switching for multiples channels

- Example:

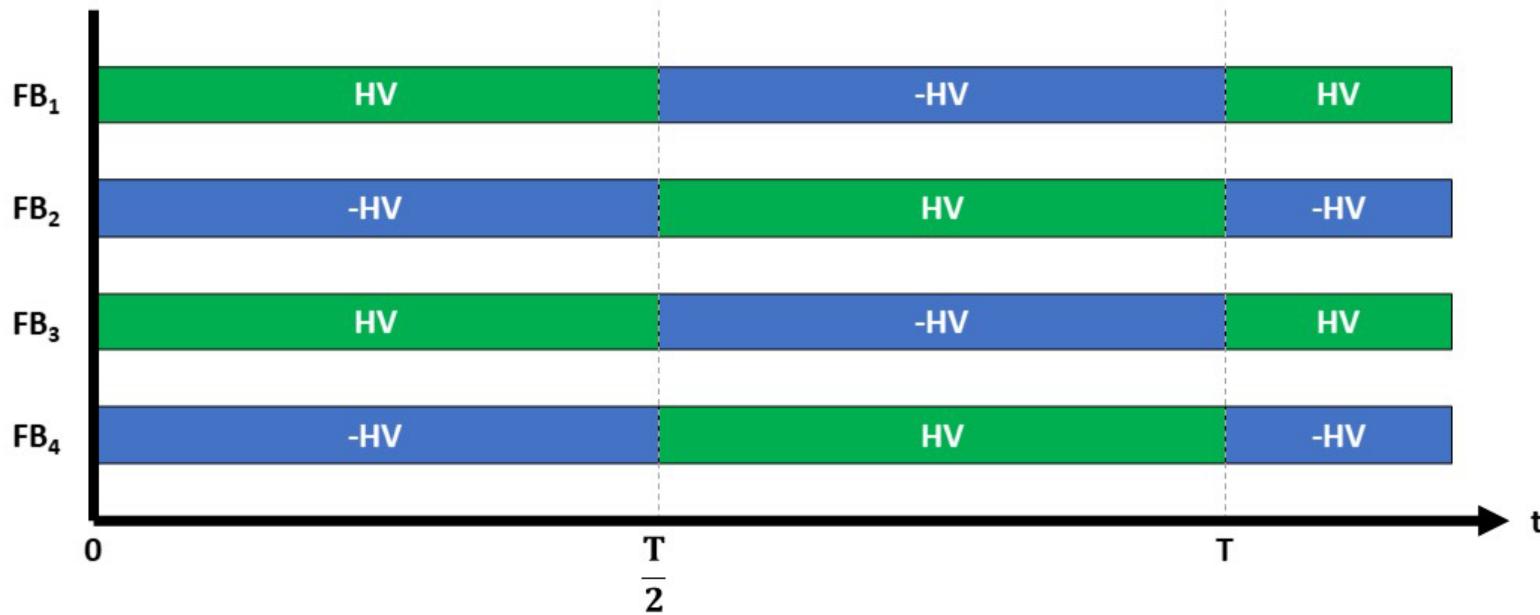
- Nb. of channels: 4
- Frequency: $x \text{ Hz}$
- PosDuty: 50 %
- Phase Pulse 180°
- NegDuty: 50 %
- Phase shift: 0 °



Firmware – Mode 4: Bipolar switching for multiples channels

- Example:

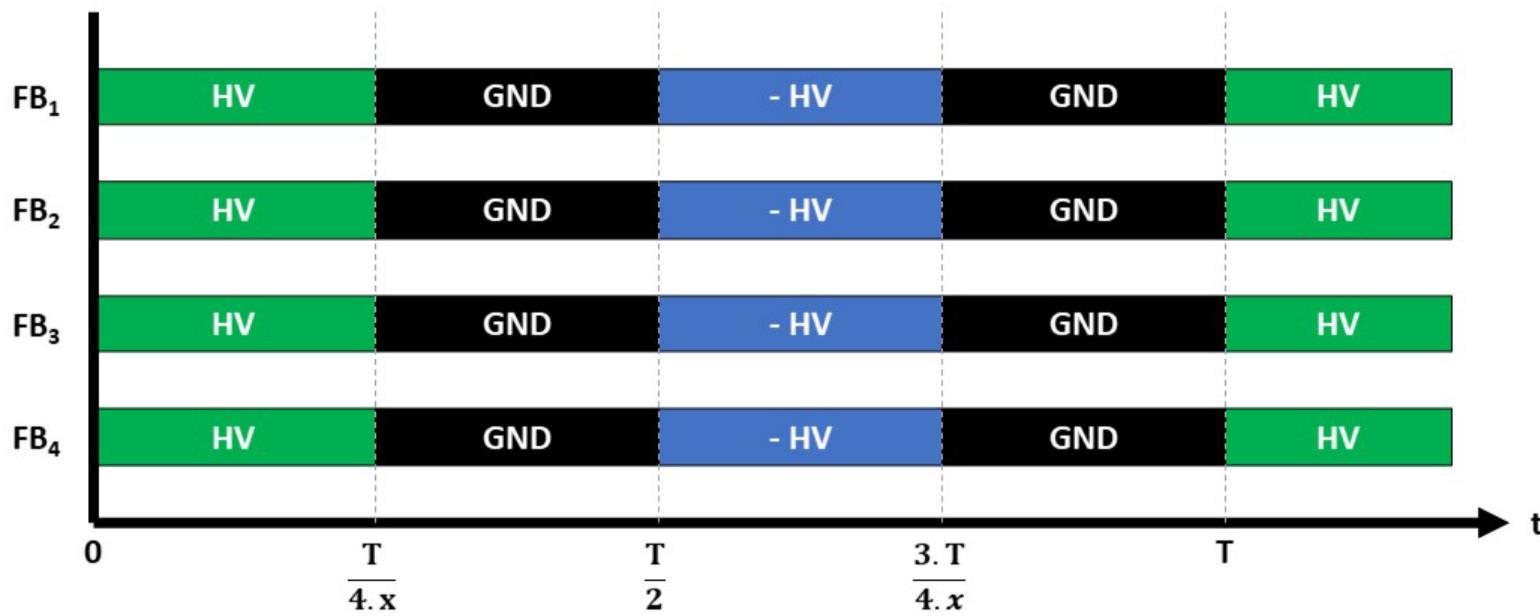
- Nb. of channels: 4
- Frequency: x Hz
- PosDuty: 50 %
- Phase Pulse 180°
- NegDuty: 50 %
- Phase shift: 180 °



Firmware – Mode 4: Bipolar switching for multiples channels

- Example:

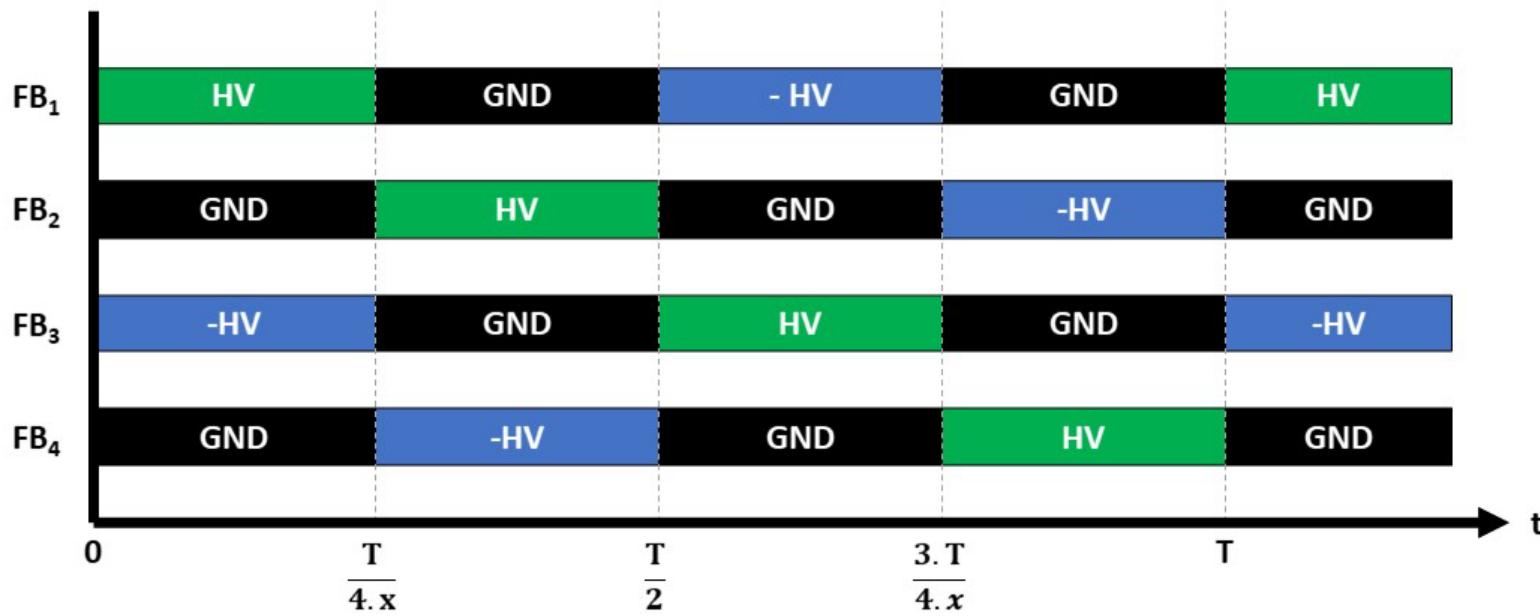
- Nb. of channels: 4
- Frequency: $x \text{ Hz}$
- PosDuty: 25 %
- Phase Pulse 180°
- NegDuty: 25 %
- Phase shift: 0 °



Firmware – Mode 4: Bipolar switching for multiples channels

- Example:

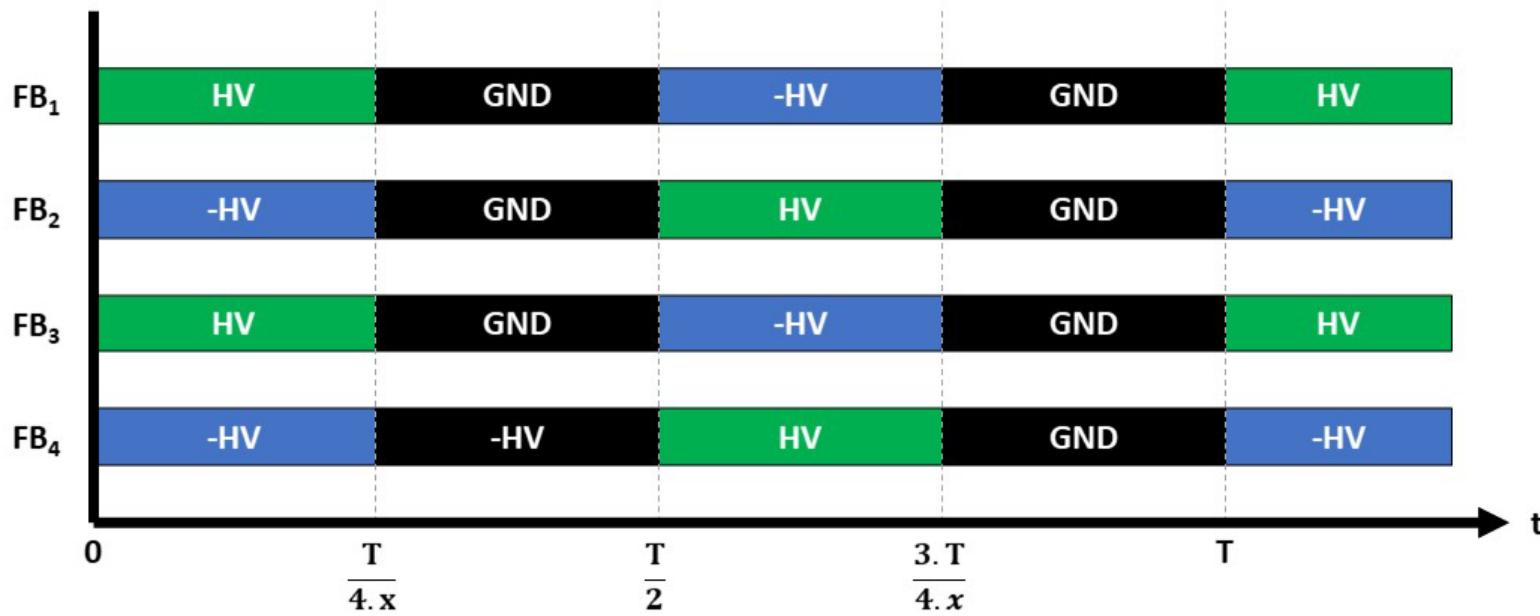
- Nb. of channels: 4
- Frequency: $x \text{ Hz}$
- PosDuty: 25 %
- Phase Pulse 180°
- NegDuty: 25 %
- Phase shift: 90 °



Firmware – Mode 4: Bipolar switching for multiples channels

- Example:

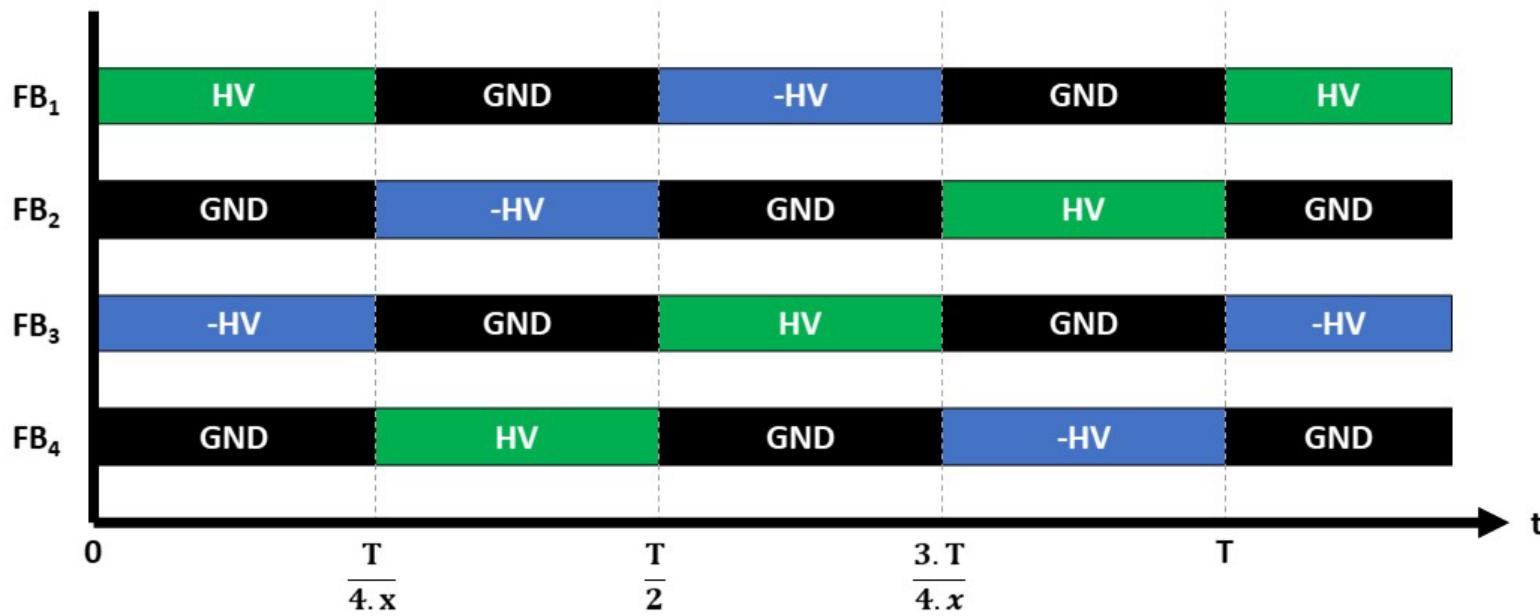
- Nb. of channels: 4
- Frequency: $x \text{ Hz}$
- PosDuty: 25 %
- Phase Pulse 180°
- NegDuty: 25 %
- Phase shift: 180 °



Firmware – Mode 4: Bipolar switching for multiples channels

- Example:

- Nb. of channels: 4
- Frequency: $x \text{ Hz}$
- PosDuty: 25 %
- Phase Pulse 180°
- NegDuty: 25 %
- Phase shift: 270 °

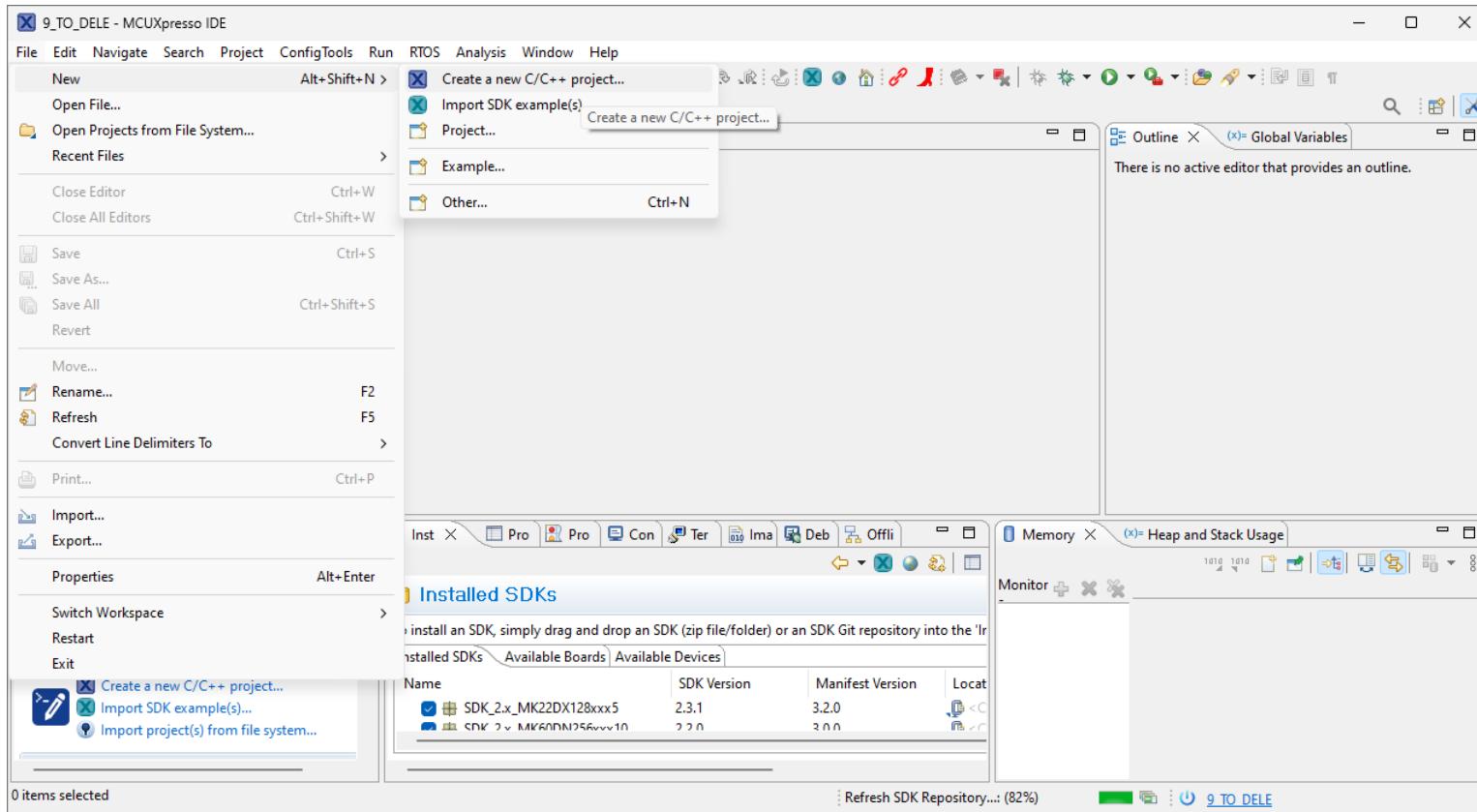


Firmware – How to flash microcontroller

- Requirements:
 - OCHVPS_v1.0 board
 - MCUXpresso IDE
 - J-LINK programmer
- Materials used:
 - MCUXpresso IDE 11.0
 - [Segger J-Link Base \(v11.0\)](#)
- STEP 1: Download, install and open [MCUXpresso IDE](#).

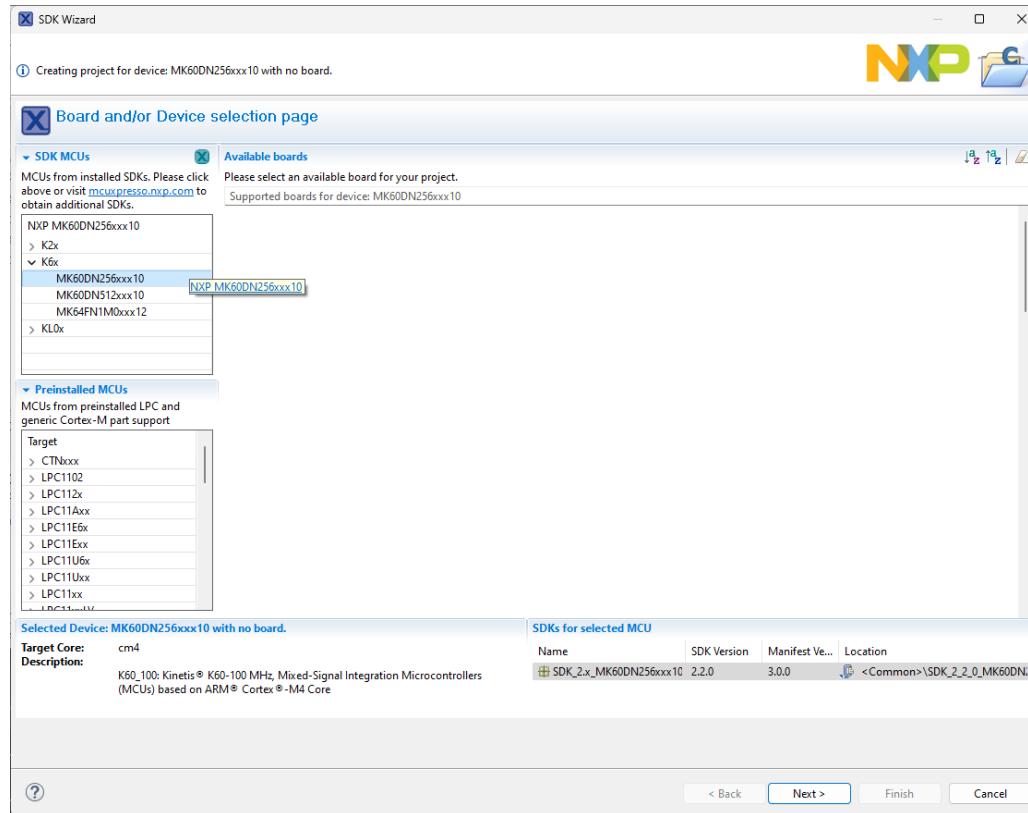
Firmware – How to flash microcontroller

- STEP 2: File => New=> Create a new C/C++ project...



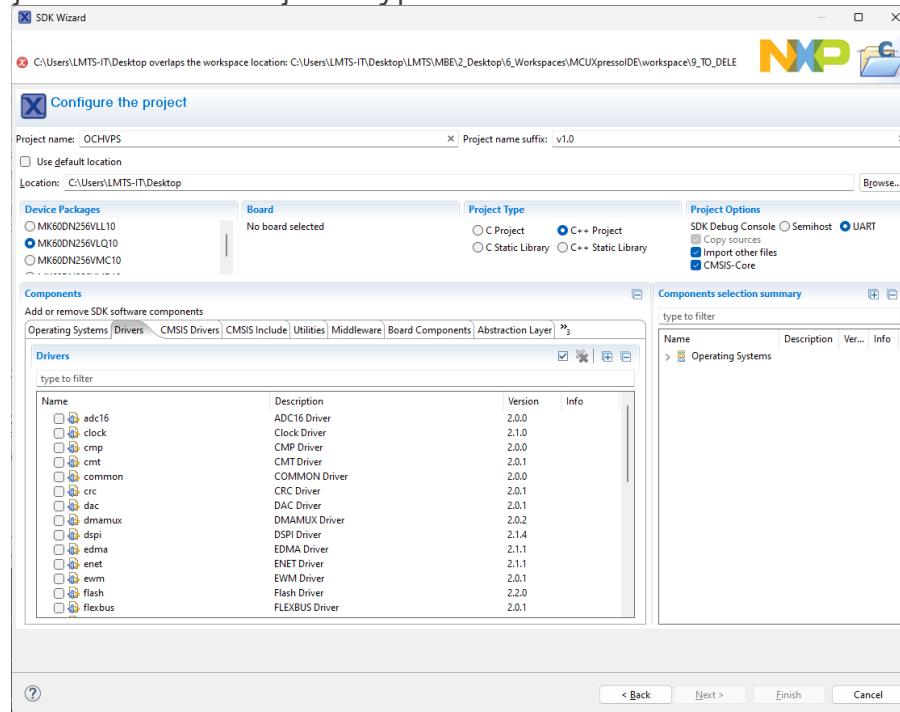
Firmware – How to flash microcontroller

- STEP 3: In SDK Wizard, under "SDK MCUs" and "Target", select "K6x" and "MK60DN256xxx10" and click on "Next"



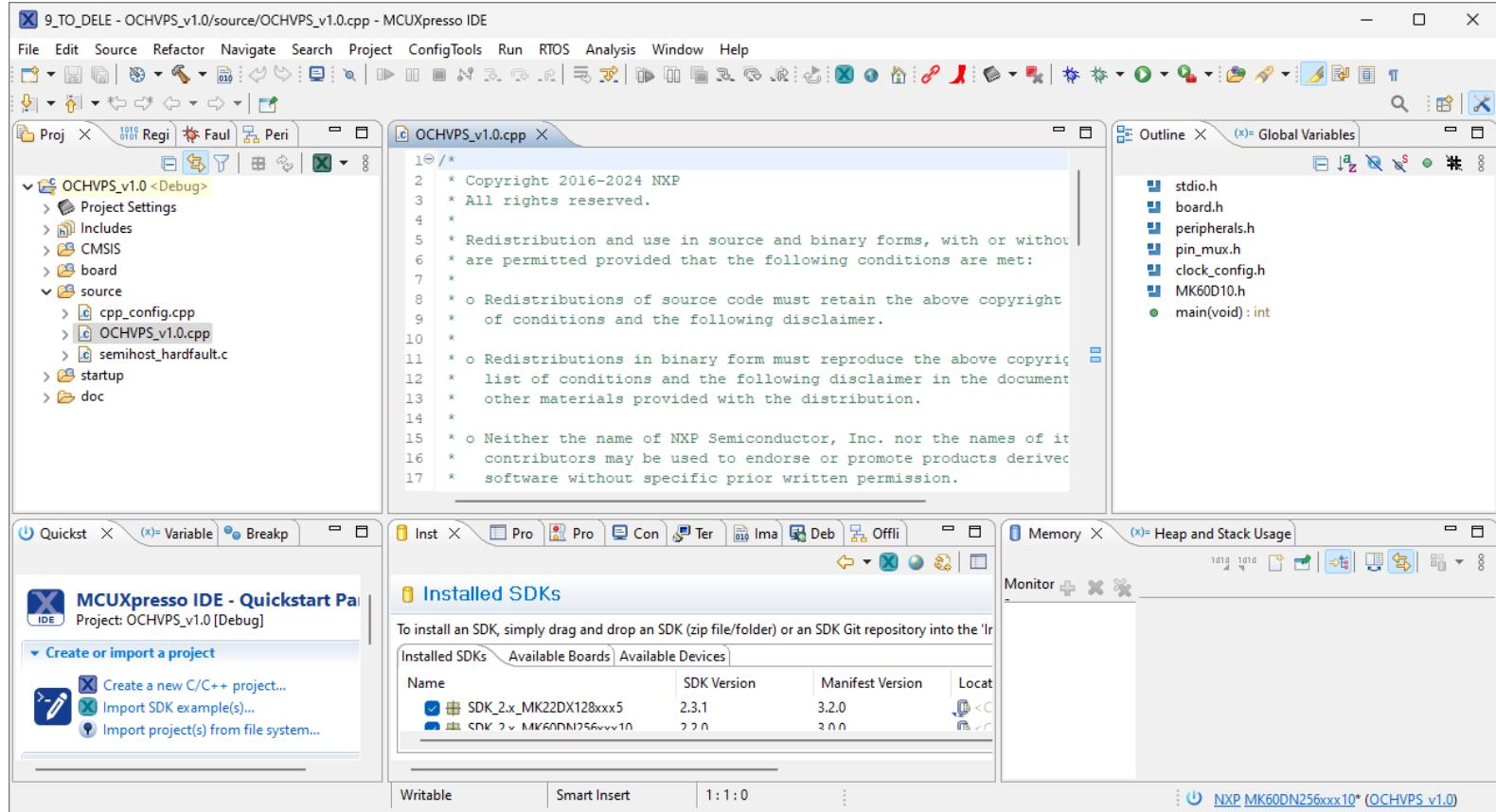
Firmware – How to flash microcontroller

- STEP 4: Give a Project name, a project name suffix (not mandatory) and set the location for your project. Then, before to click on “Finish”, select:
 - "MK60DN256VLQ10" under "device Packages"
 - "C++ Project" under "Project Type"



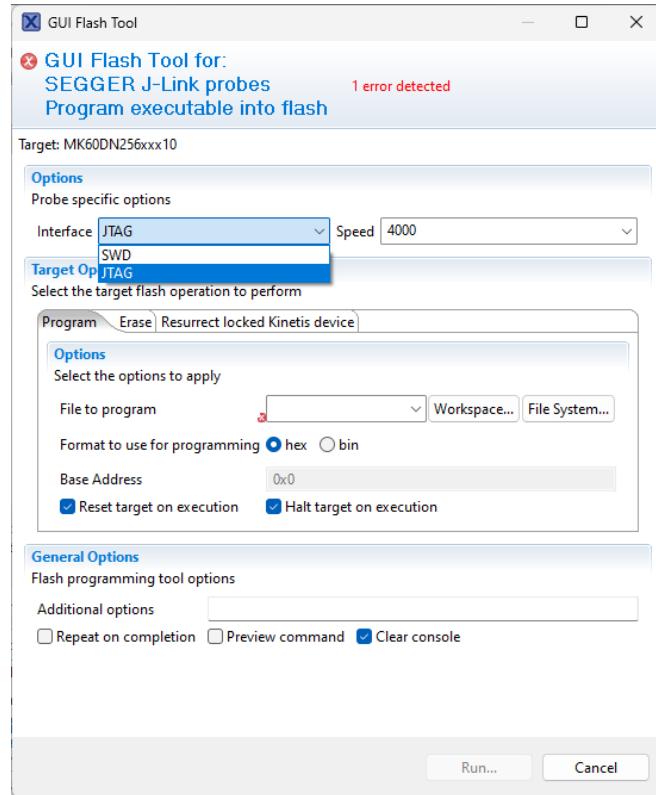
Firmware – How to flash microcontroller

- STEP 5: Click on the "GUI Flash Tool" icon



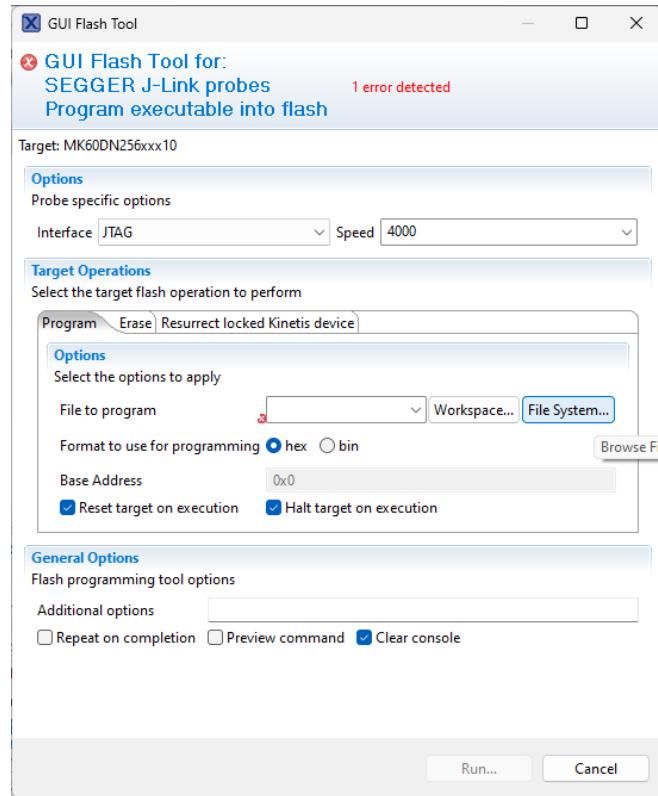
Firmware – How to flash microcontroller

- STEP 6: In the "File to program" edit text, select "JTAG"



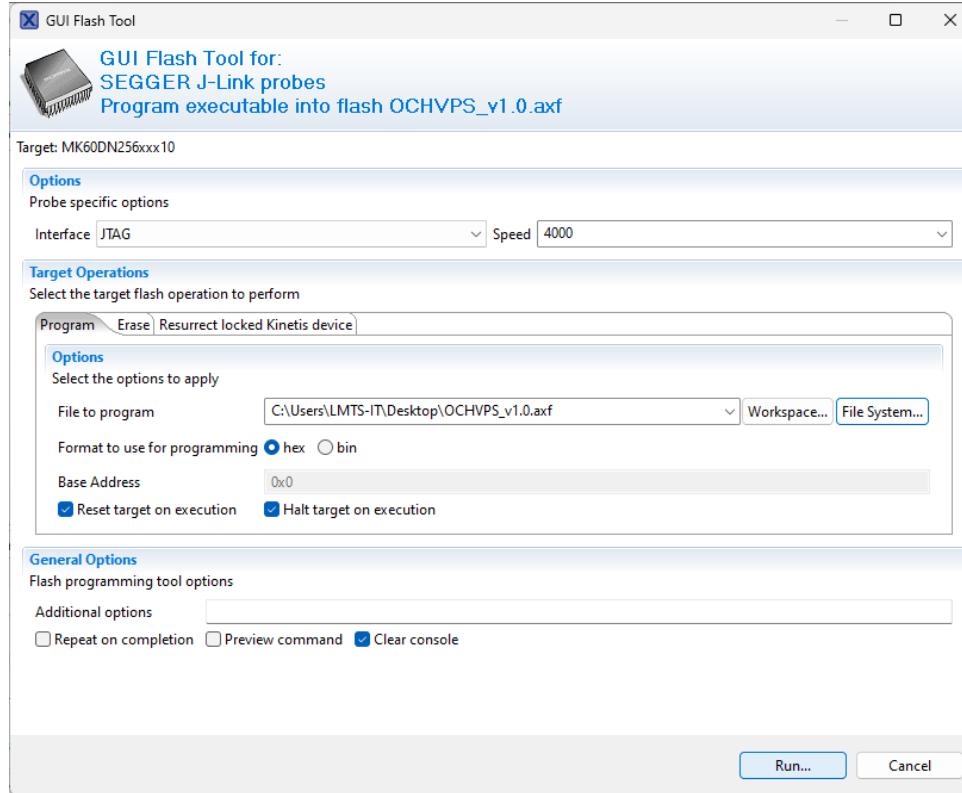
Firmware – How to flash microcontroller

- STEP 7: In the "File to program" edit text, click on File System and choose the "OCHVPS_v1.0.axf file



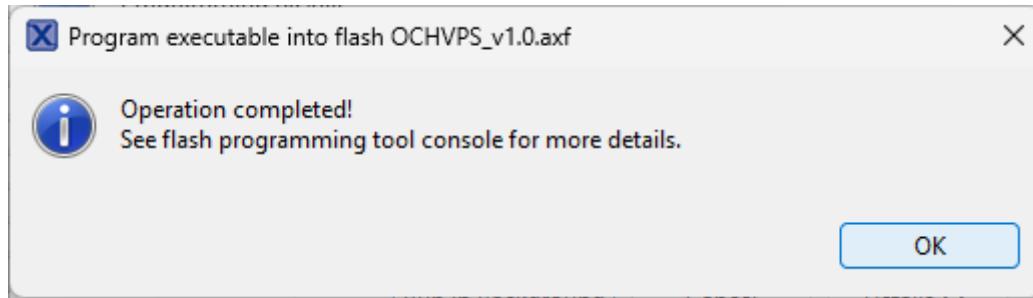
Firmware – How to flash microcontroller

- STEP 8: Click on "Run..." button



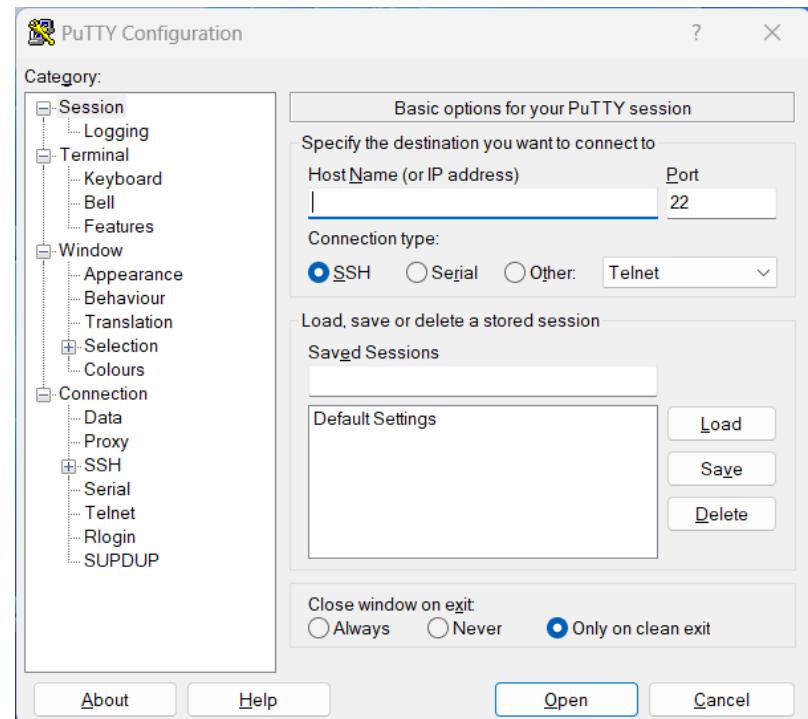
Firmware – How to flash microcontroller

- STEP 9: Click on "OK"



Firmware – How to setup microcontroller

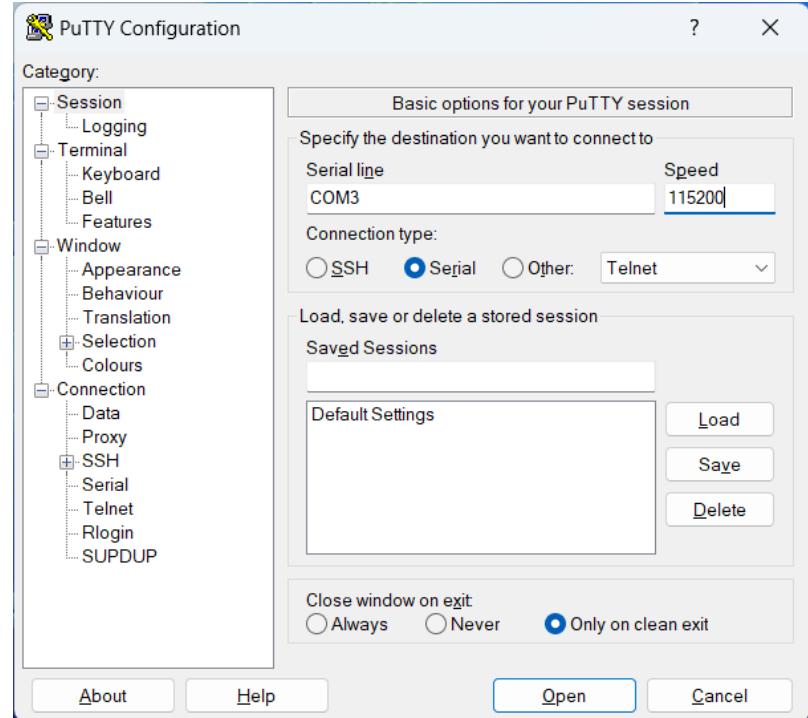
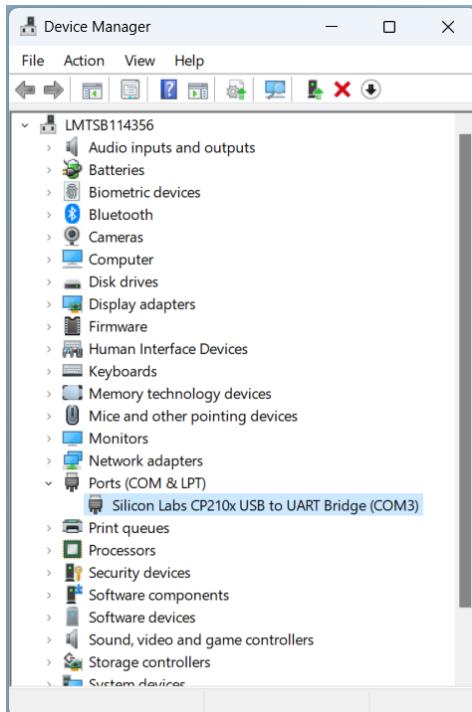
- Once the microcontroller has been flashed, you must configure the board with [PuTTY](#).
- STEP 1: Download, install and open [PuTTY](#).



Firmware – How to setup microcontroller

- STEP 2:

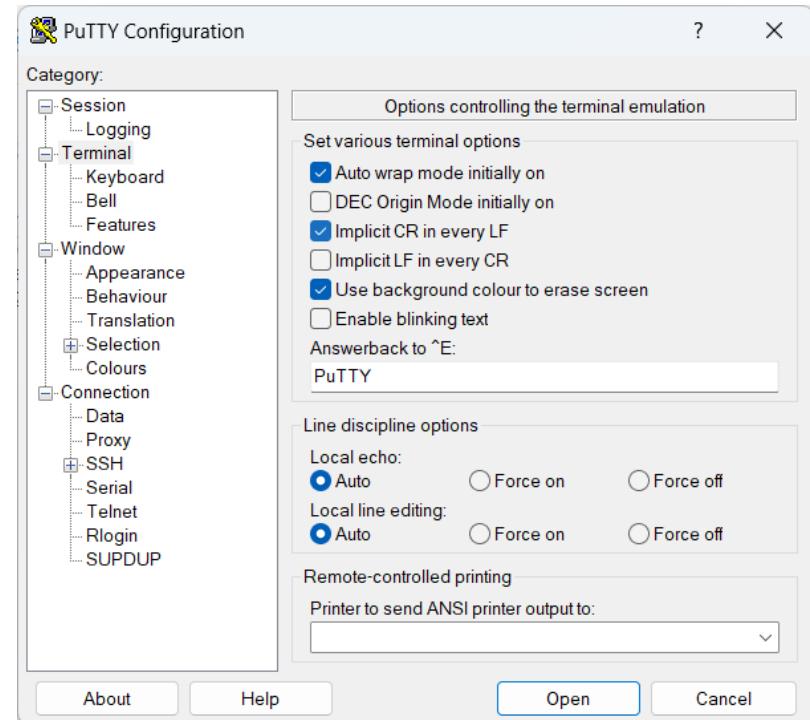
- Select “Serial” as connection type,
- Enter the right COM port (Board communication port number can be found under Ports, in Device Manager)



Firmware – How to setup microcontroller

- STEP 3:

- In the "Terminal" category, select "Implicit CR in every LF"



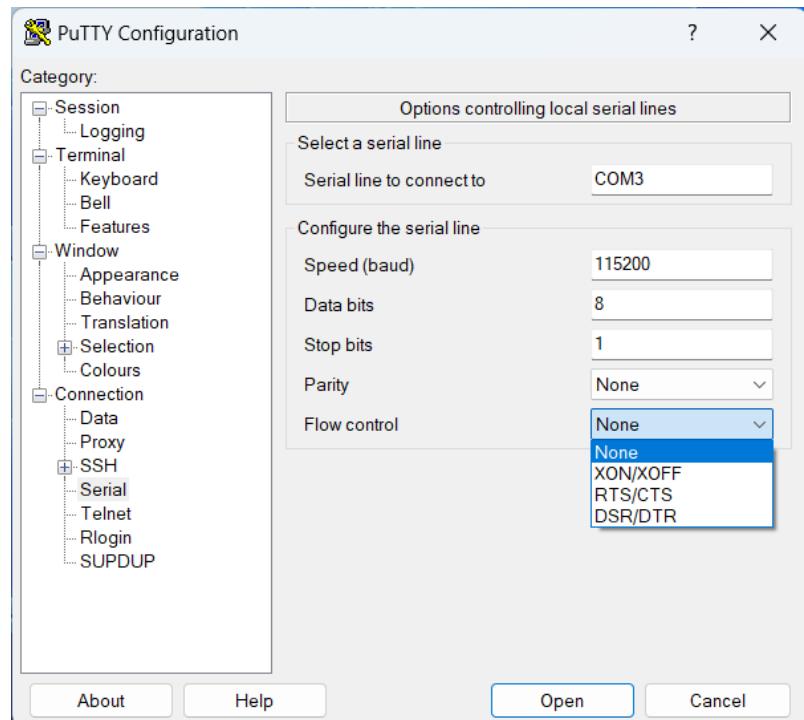
Firmware – How to setup microcontroller

- STEP 4:

➤ Fill the different parameters in the "Serial" category with:

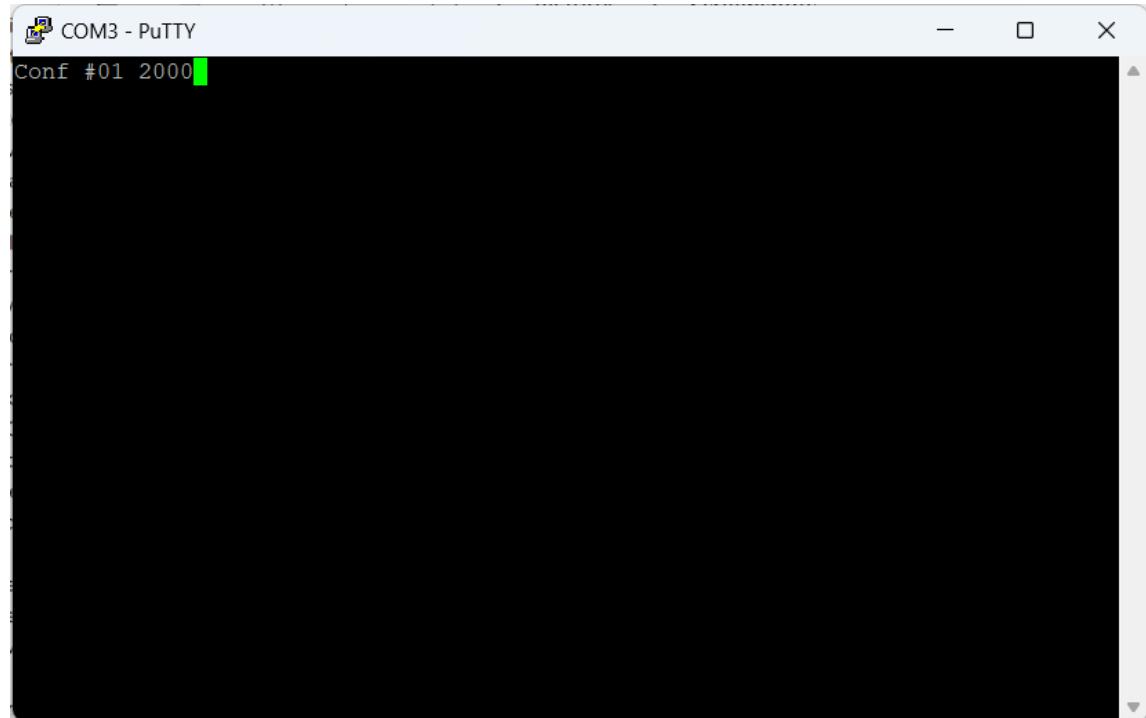
- Speed = 115200
- Data bits = 8
- Stop bits = 1
- Parity = None
- Flow control = None

➤ Then, click on "Open".



Firmware – How to setup microcontroller

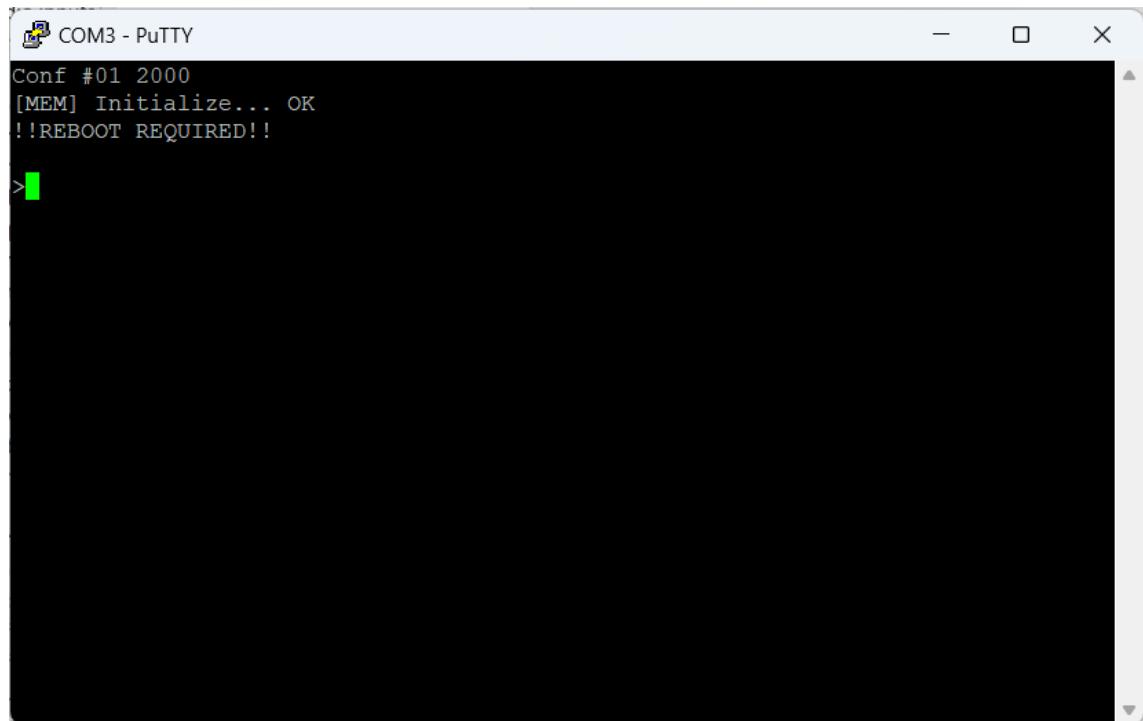
- STEP 5:
 - In the PuTTY terminal, write "Conf X 2000 ", where X represents the name of your board (choose a nice one ;)



Firmware – How to setup microcontroller

- STEP 6:

- An information message will prompt you to restart the board. Restart it.



Firmware – How to setup microcontroller

- STEP 7:

- Once the power supply restarted, you can enter the command “QPRM” to display information about the board. The setup is done and your power supply is ready to be used.

```
COM3 - PuTTY
Conf #01 2000
[MEM] Initialize... OK
!!REBOOT REQUIRED!!

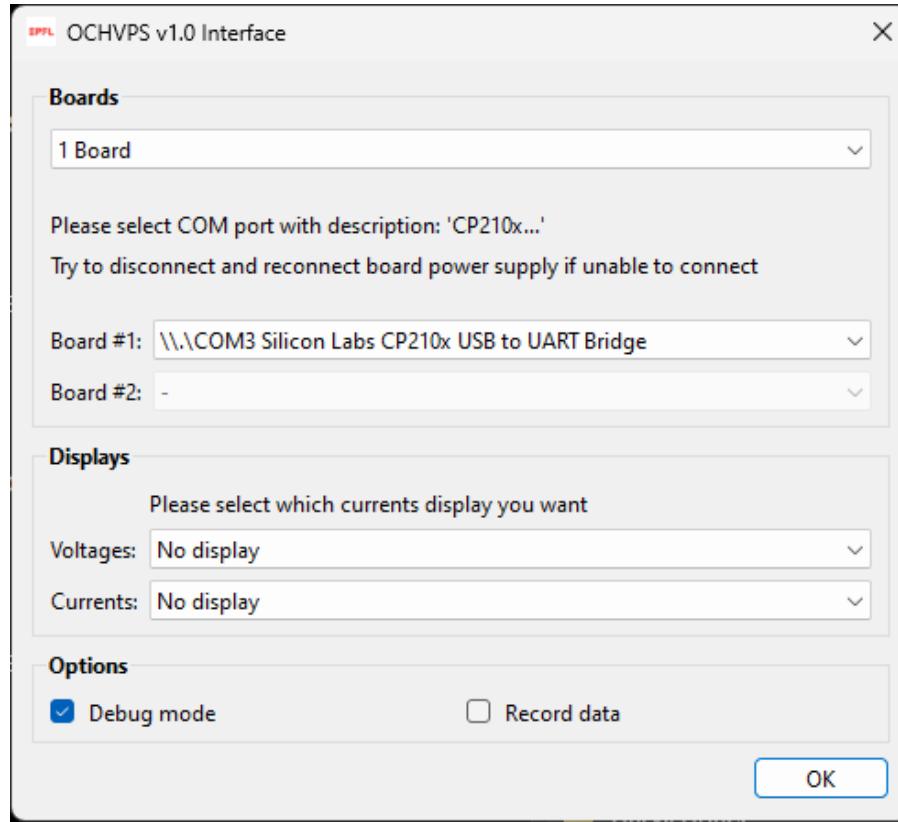
>

RESTART

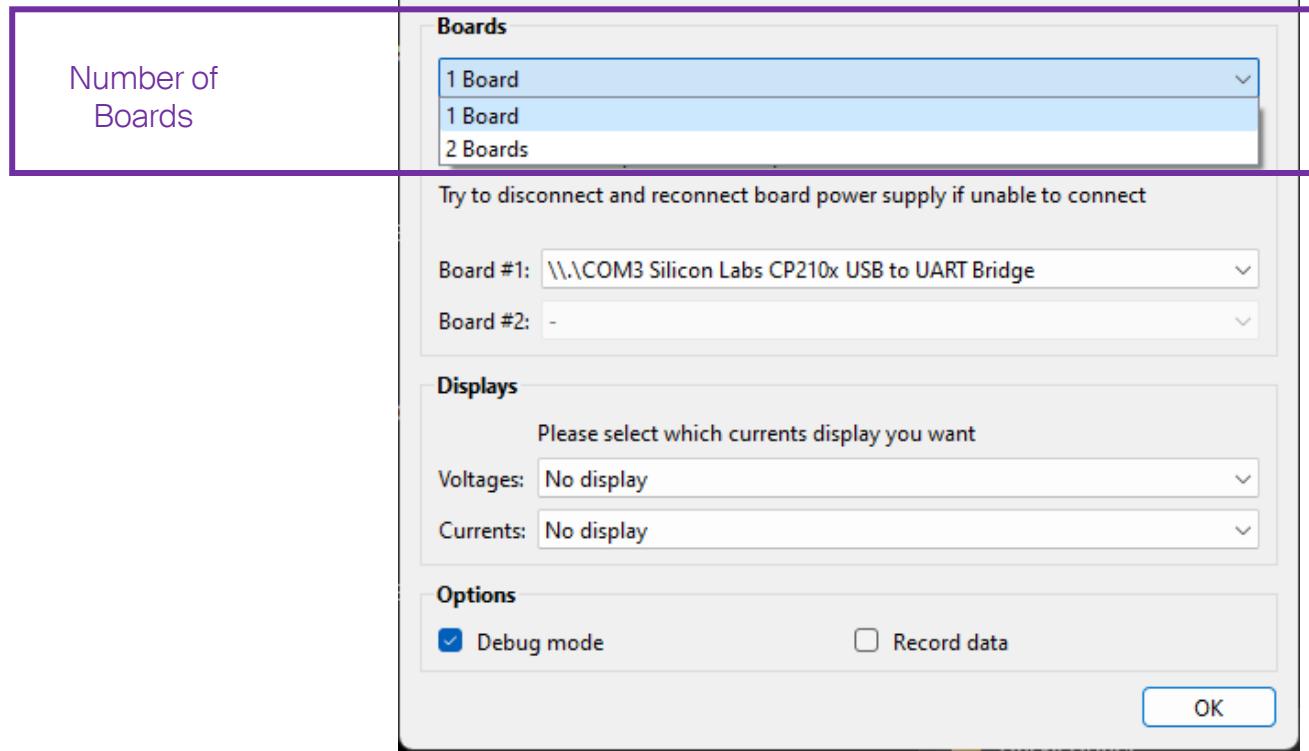
QPRM
[ PRM] PCB          #01
[ PRM] HW Version   v1.0
[ PRM] FW Version   v1.00 - 20.03.2024
[ PRM] MAX HV        (V) 2000.0
[ PRM] MIN HV        (V) 350.0
[ PRM] MAX FREQ      (Hz) 1000.0
[ PRM] MIN FREQ      (Hz) 0.01
[ PRM] MIN PULSE     (us) 500.0

>
```

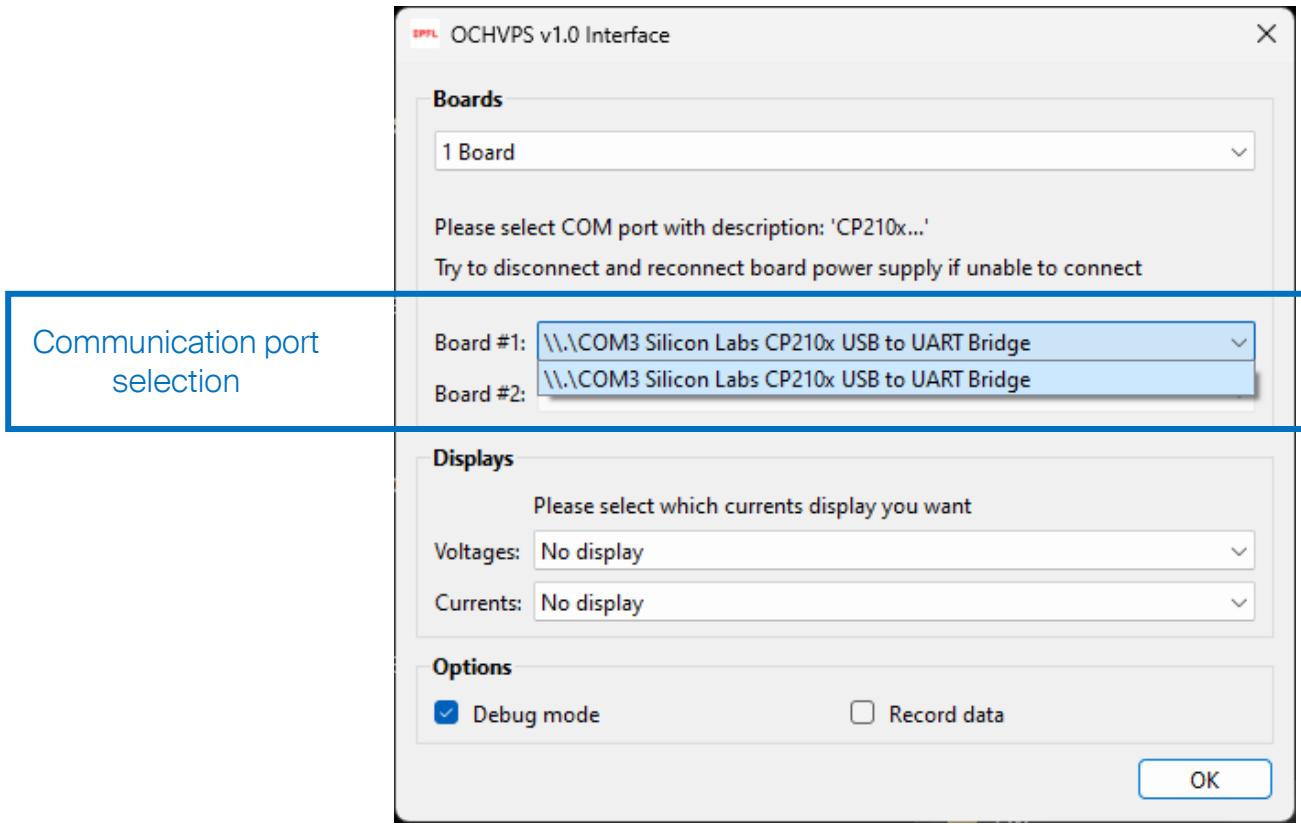
Software – Selection window



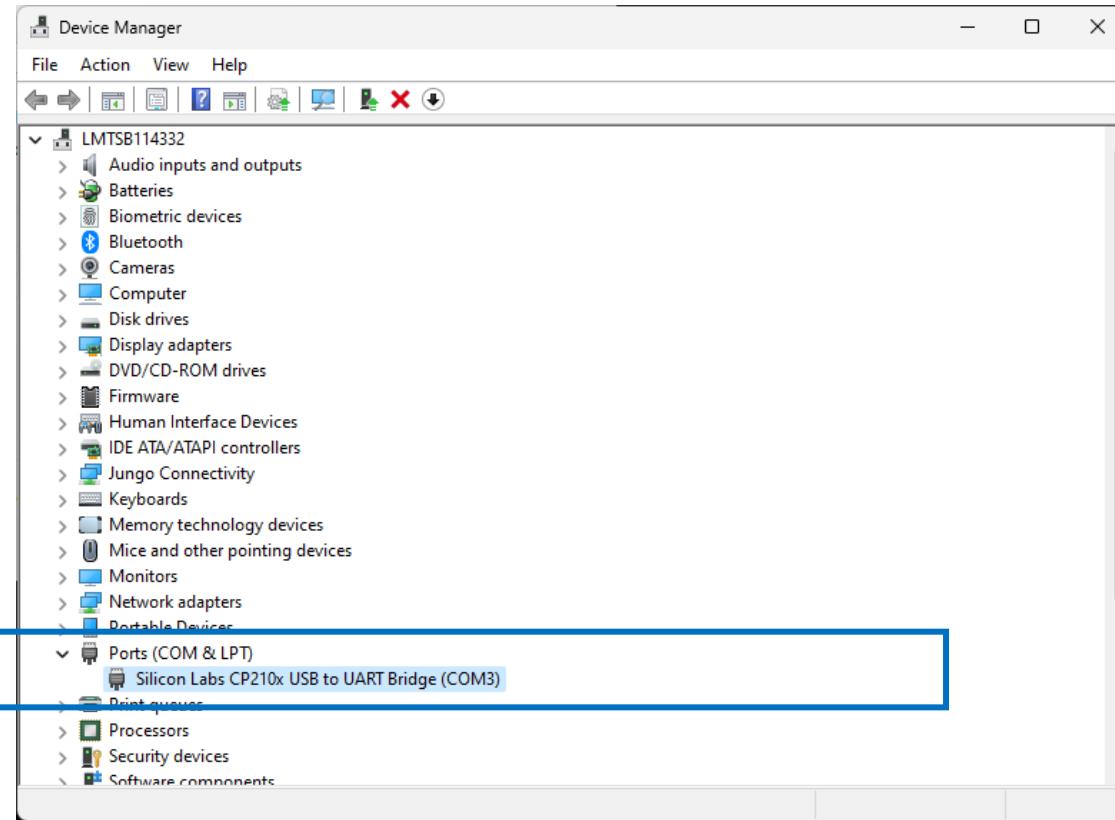
Software – Selection window



Software – Selection window



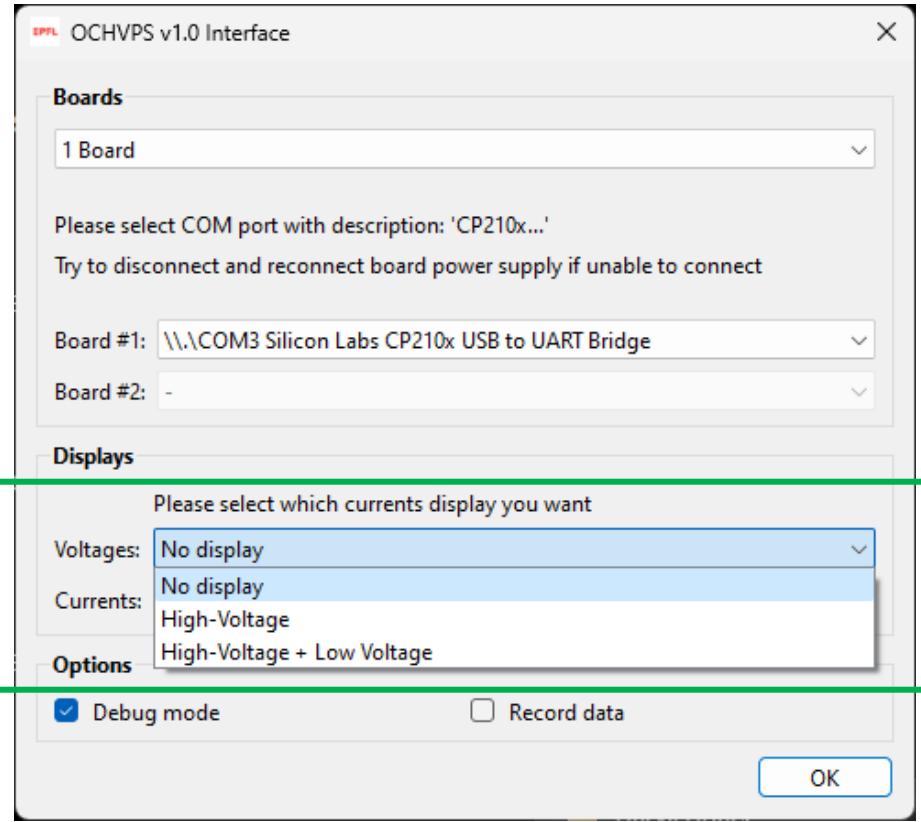
Software – Selection window



Board communication port(s) number can be found under Ports, in Device Manager.

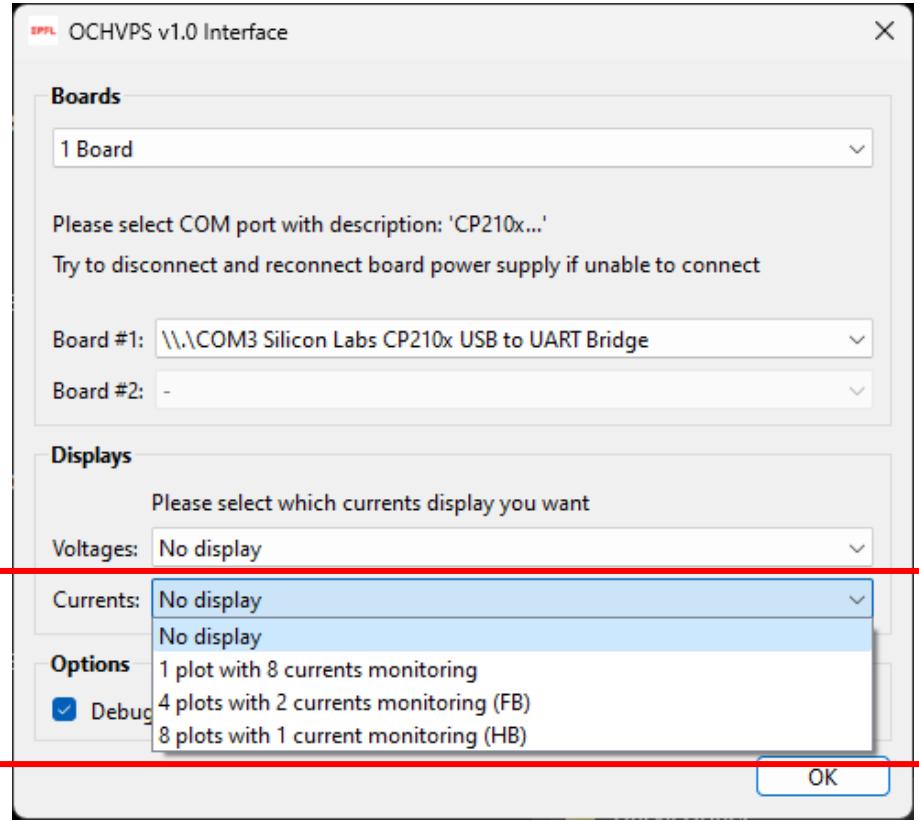
You will need to select the "CP210x"

Software – Selection window

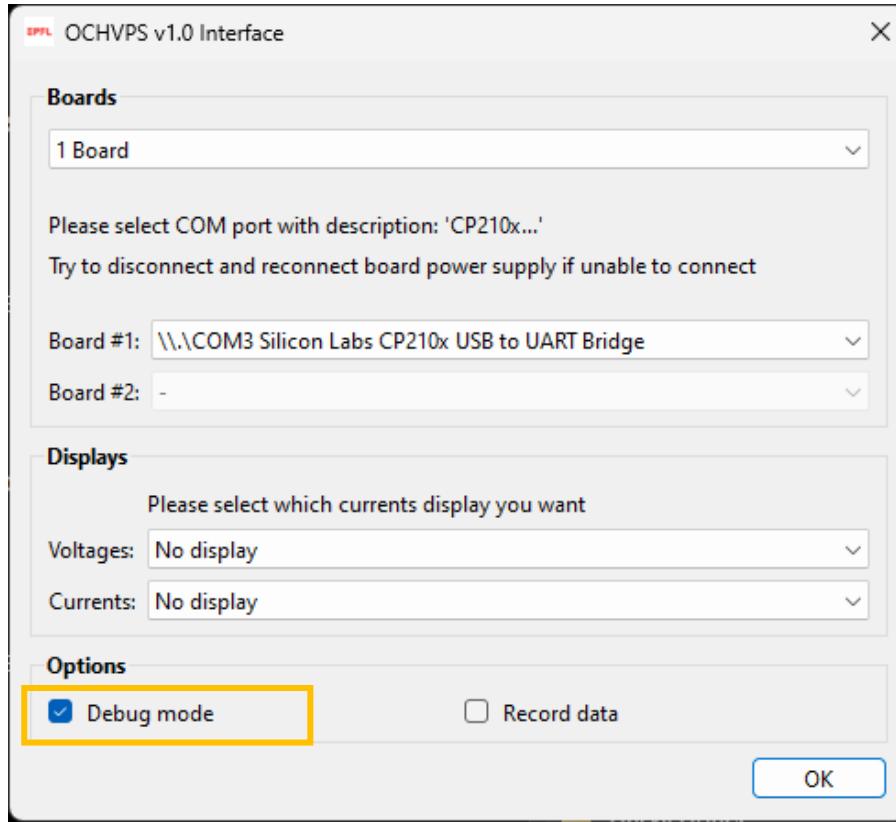


Voltage plots selection

Software – Selection window

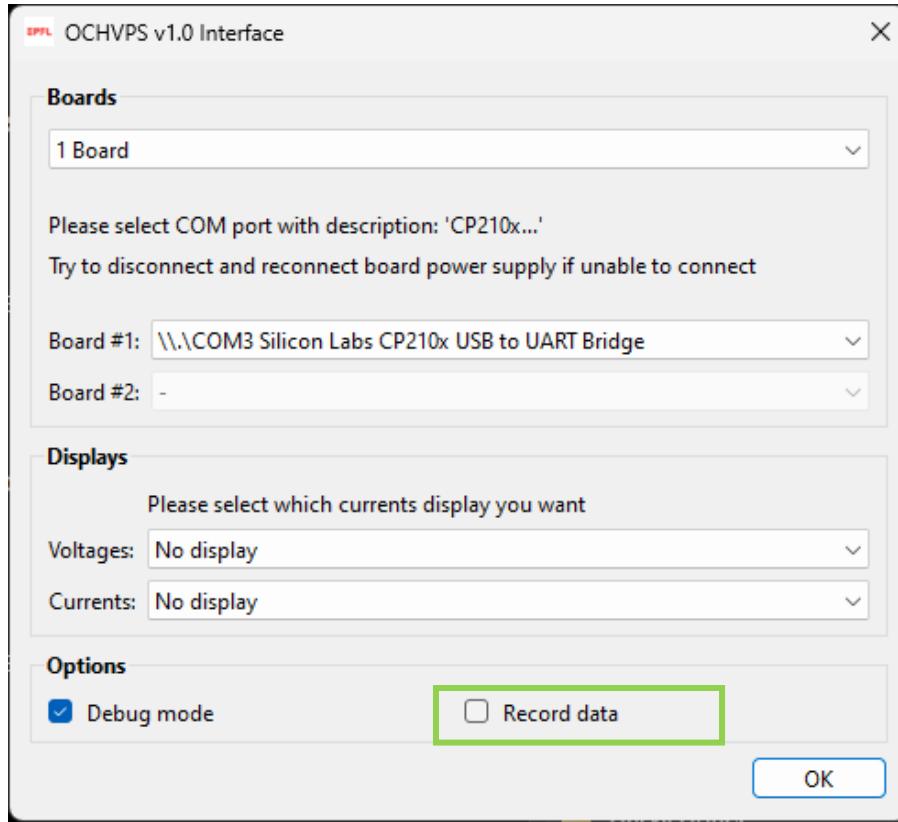


Software – Selection window



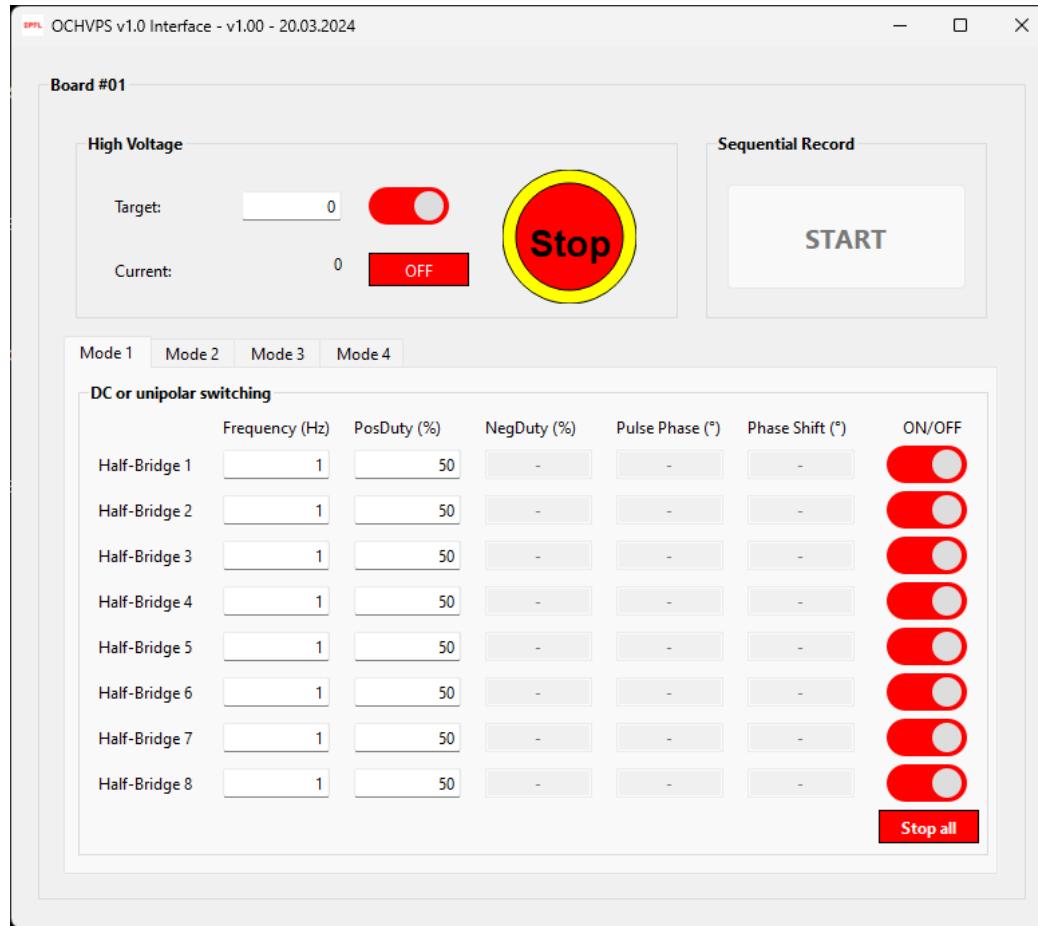
Debug Mode:
Display information in terminal

Software – Selection window

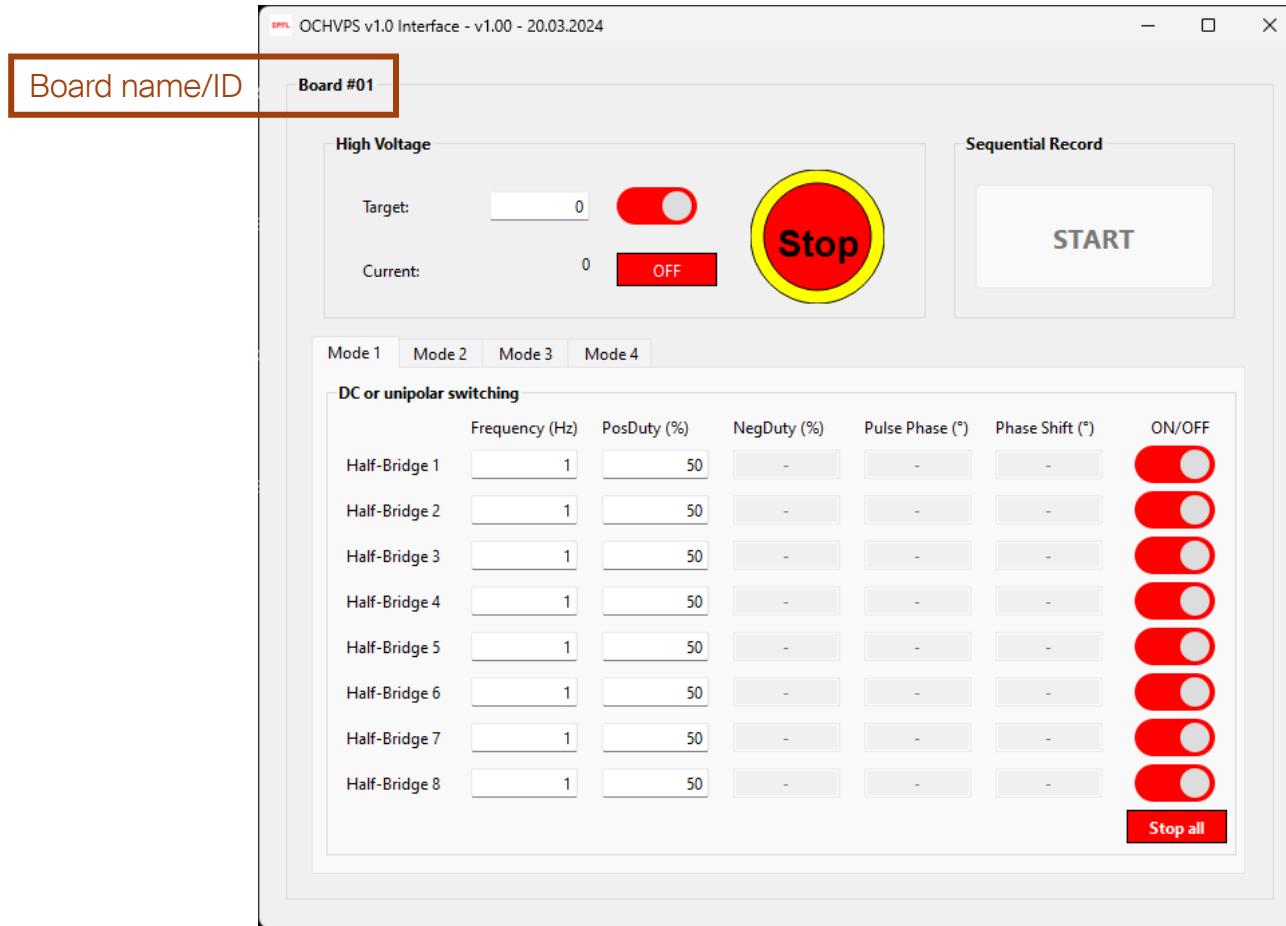


Record data:
Record all received data by software into a file and possibility to sequential record

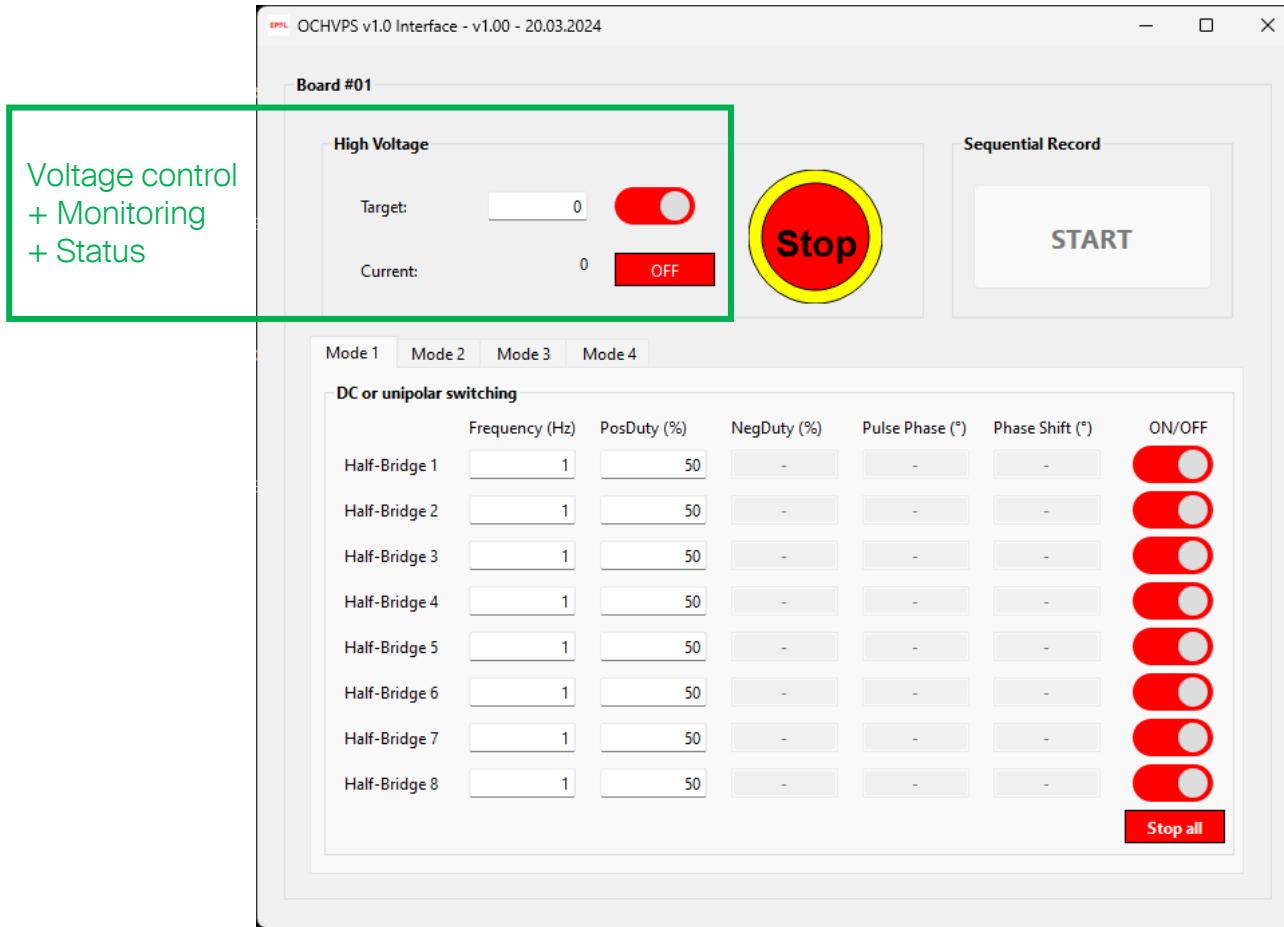
Software – Main window: 1 board and no plot



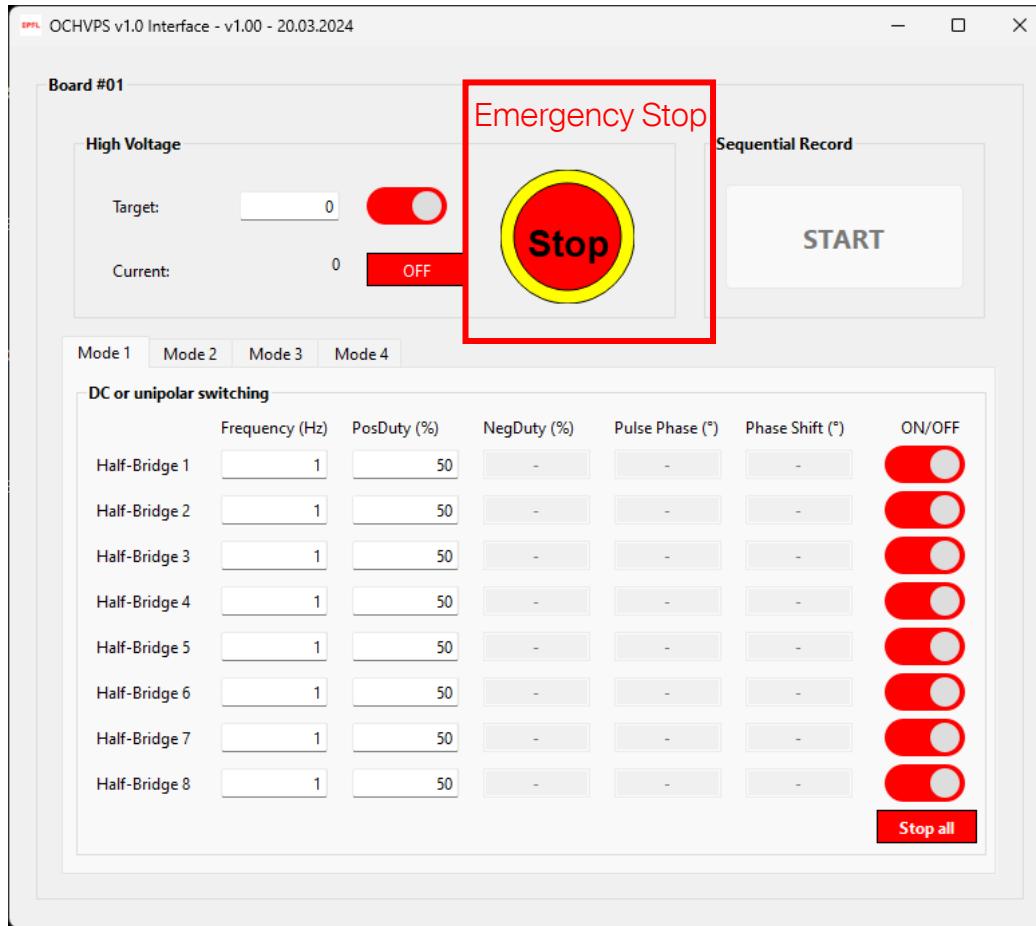
Software – Main window: 1 board and no plot



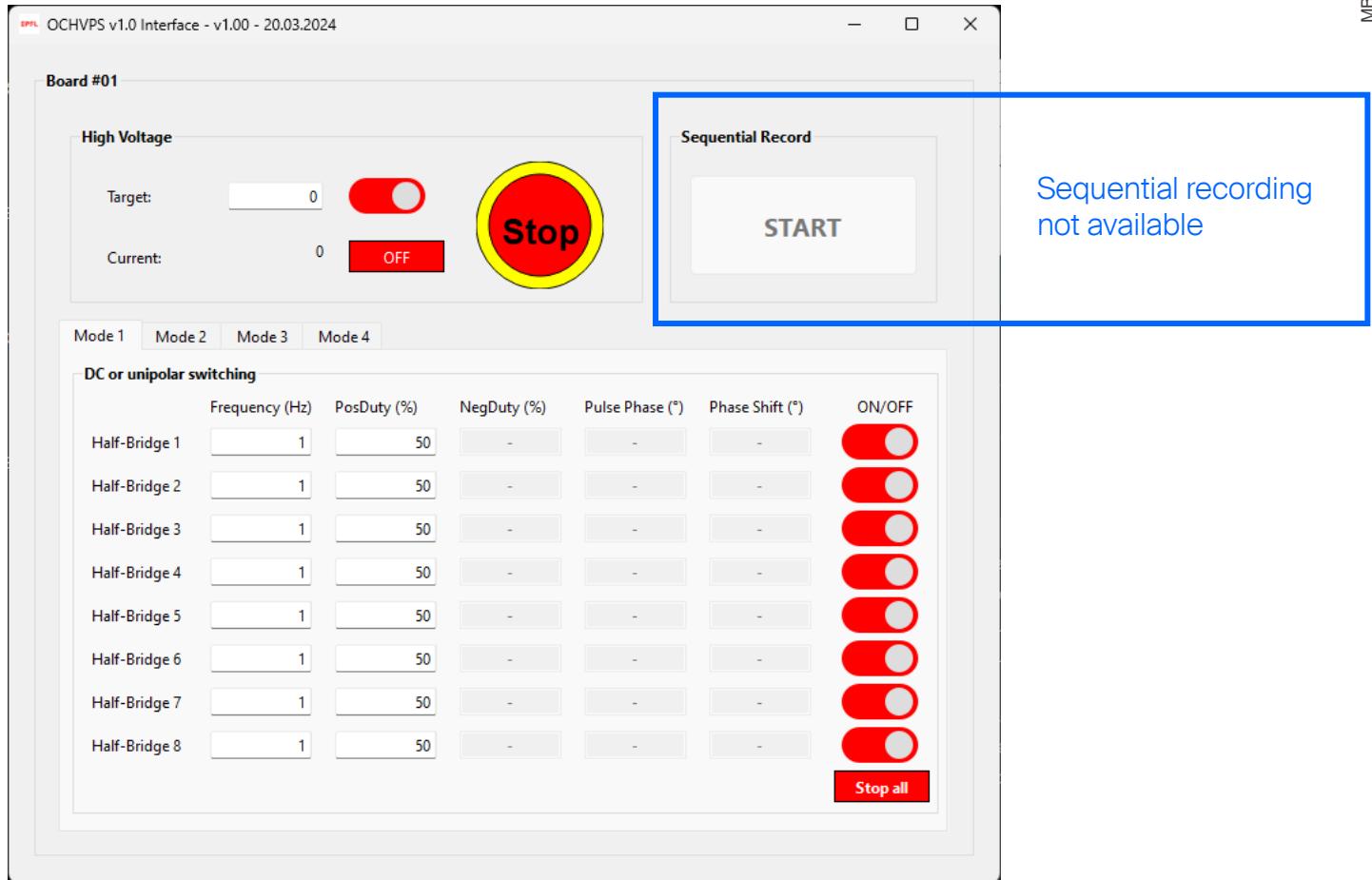
Software – Main window: 1 board and no plot



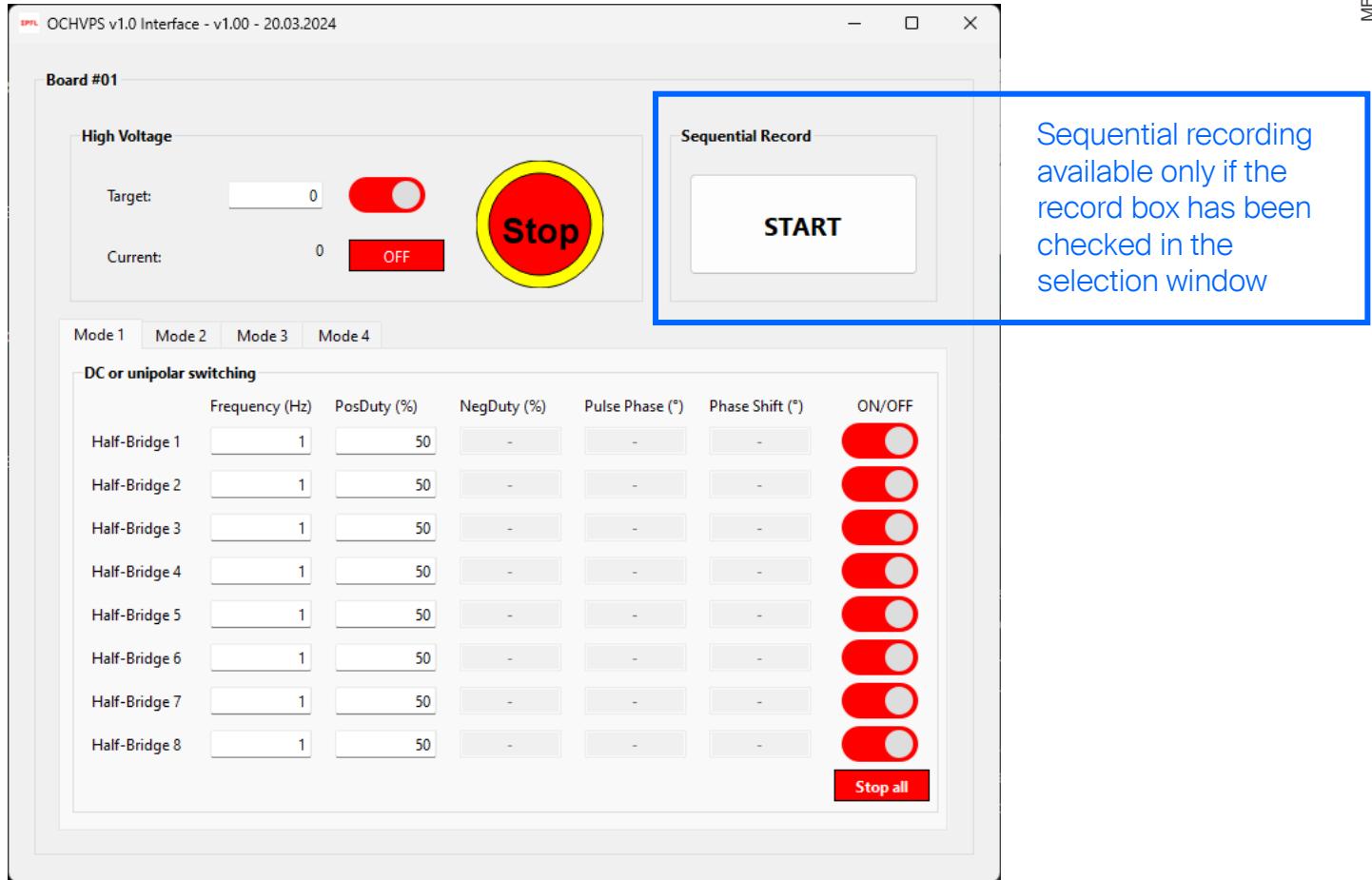
Software – Main window: 1 board and no plot



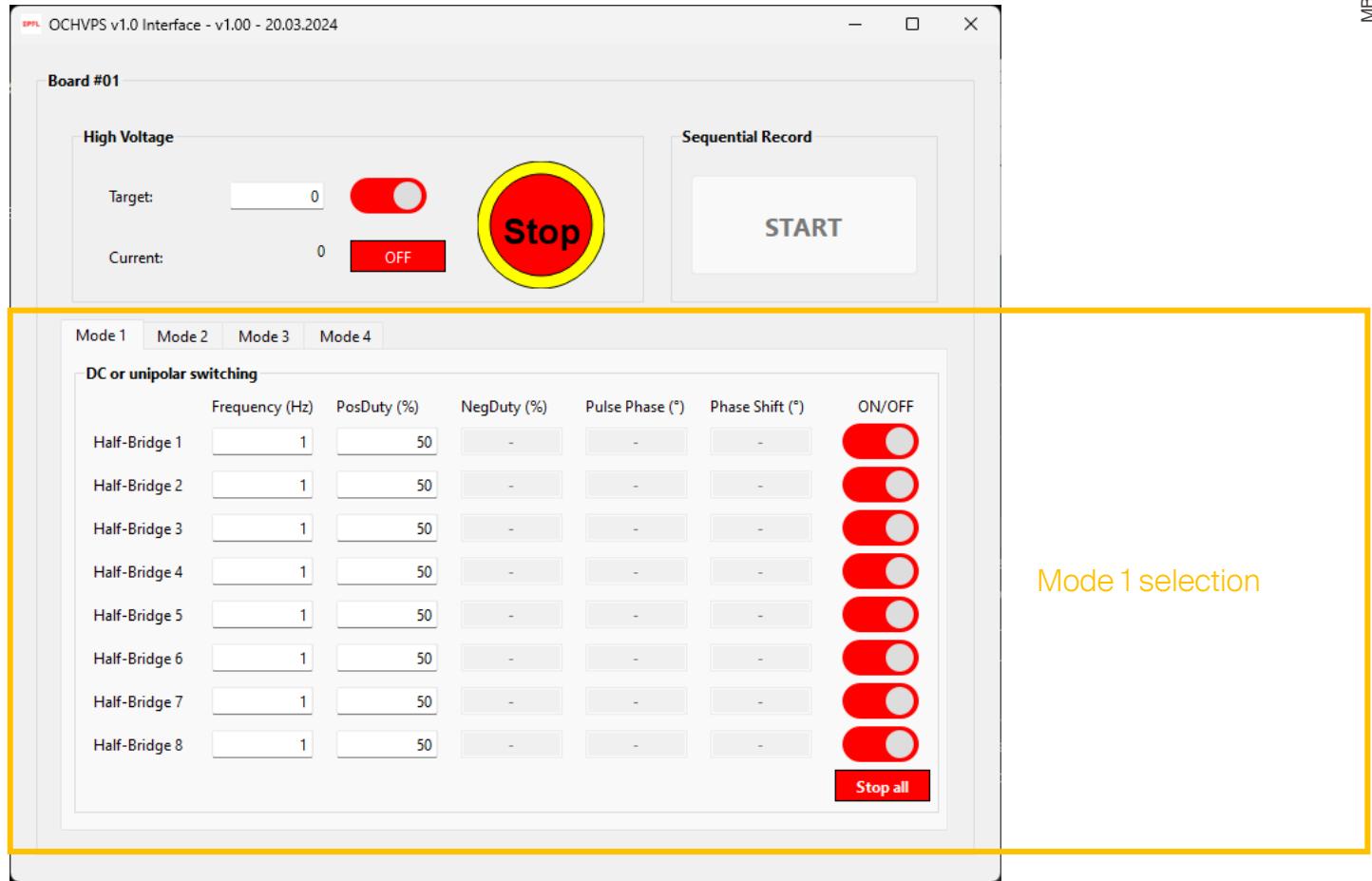
Software – Main window: 1 board and no plot



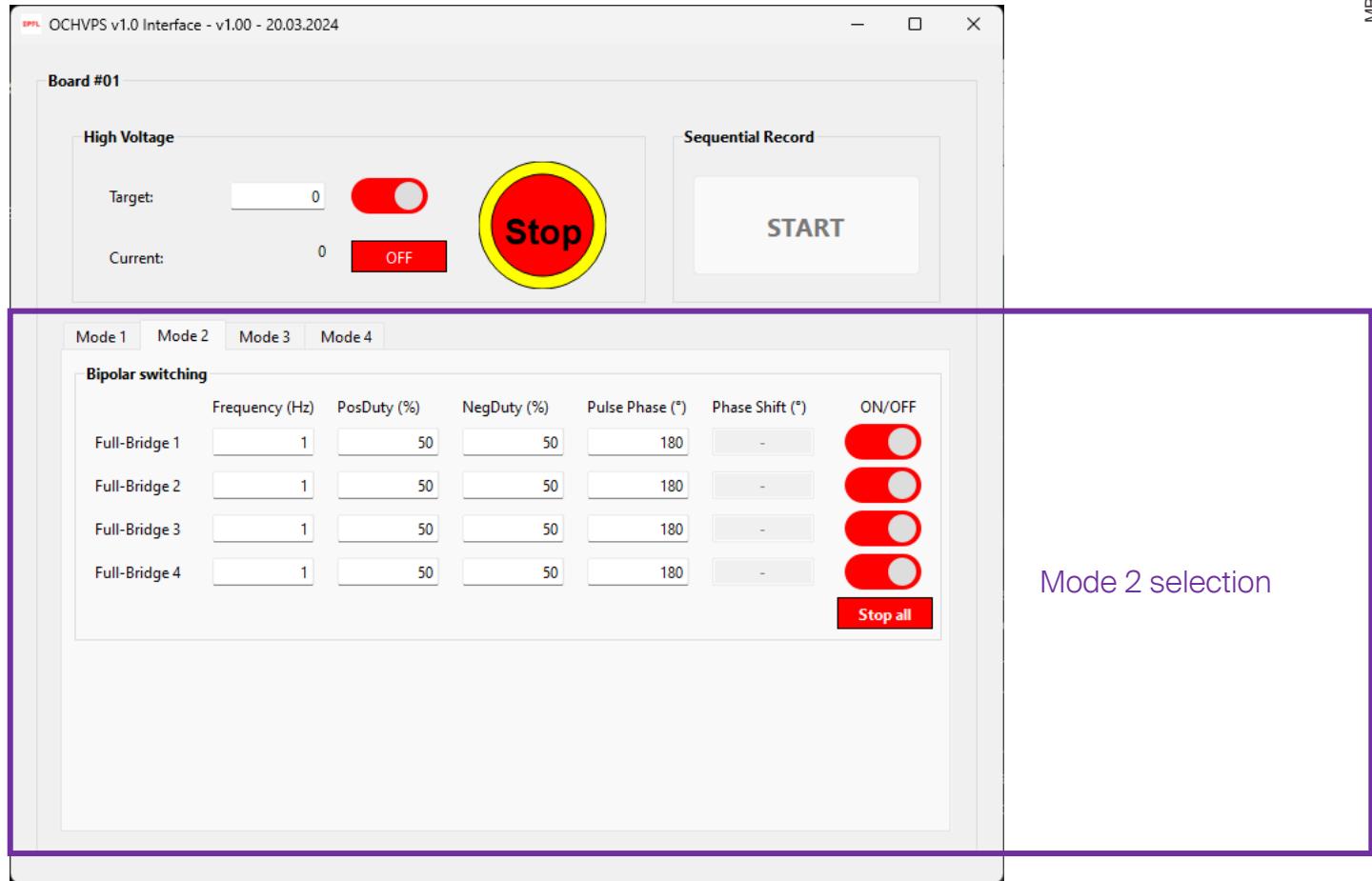
Software – Main window: 1 board and no plot



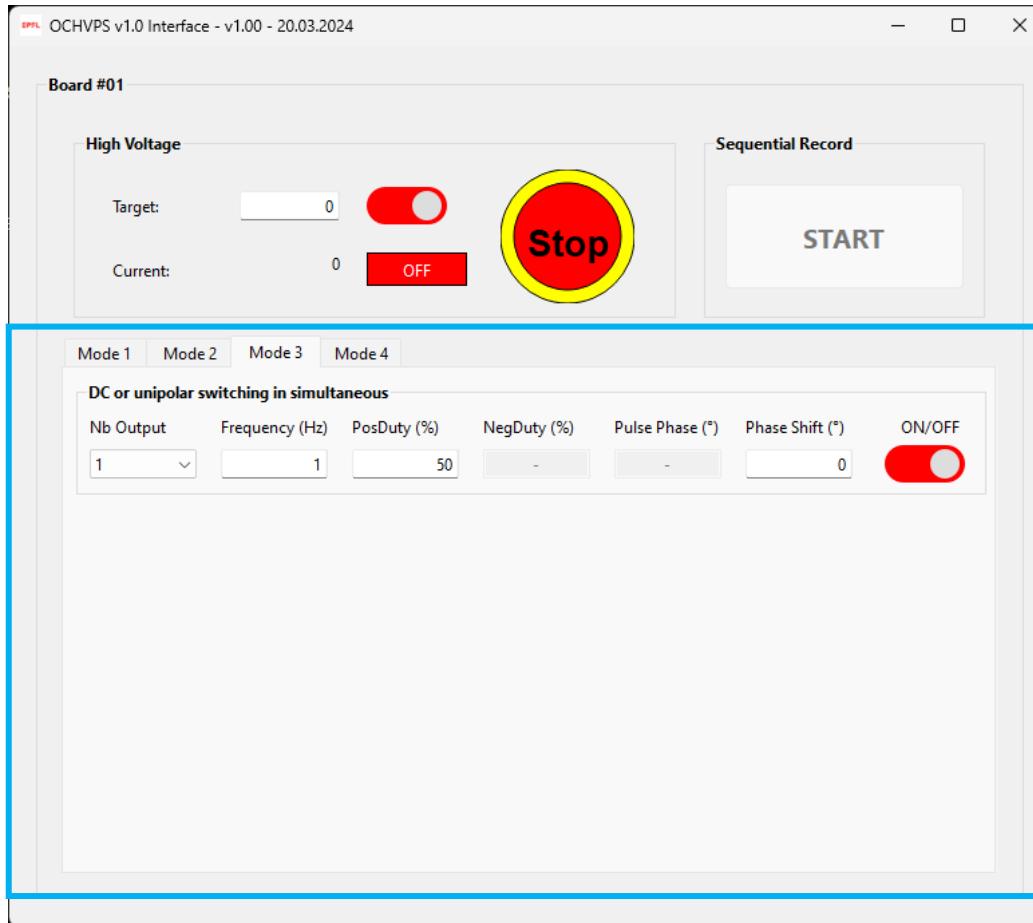
Software – Main window: 1 board and no plot



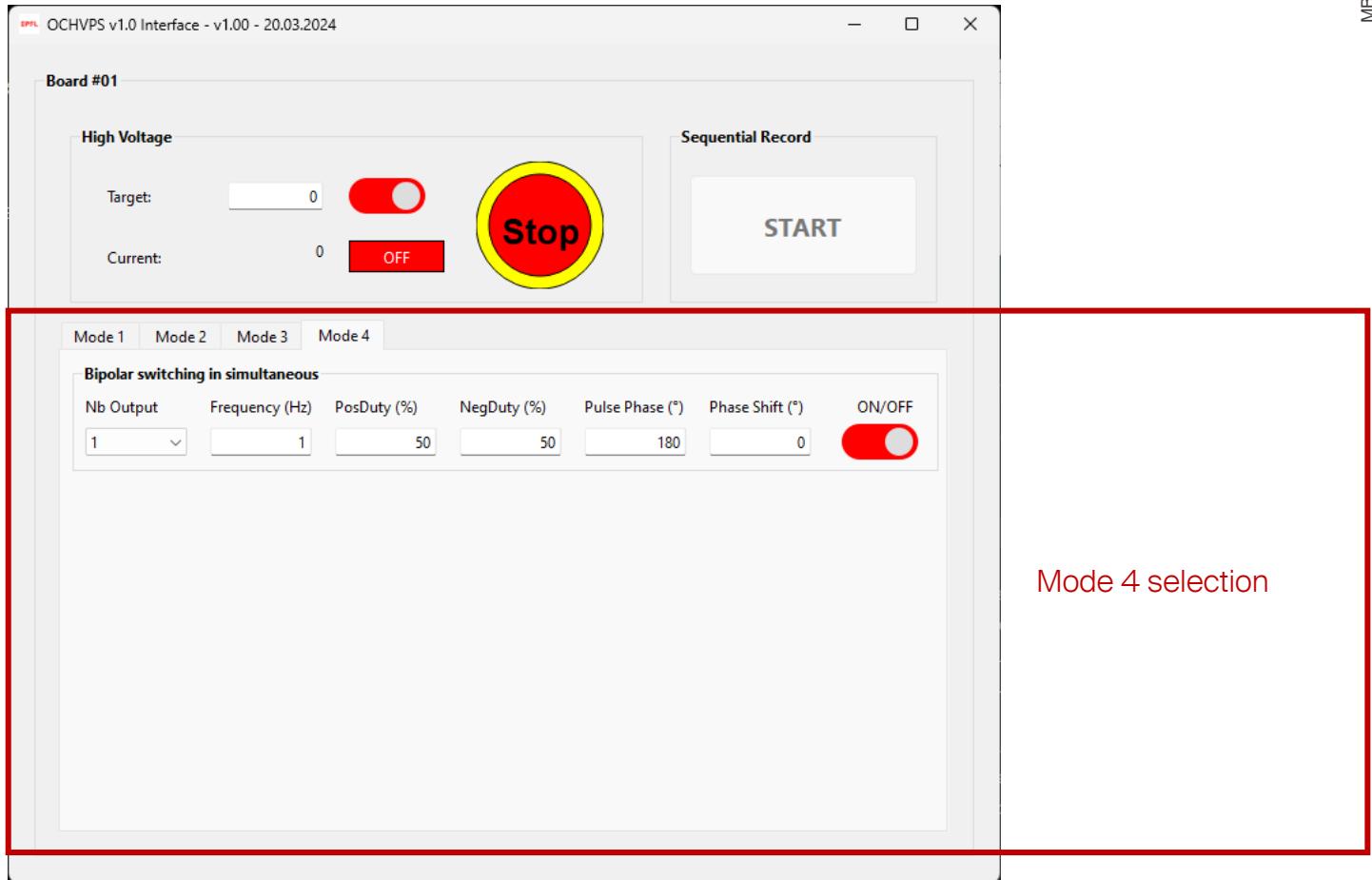
Software – Main window: 1 board and no plot



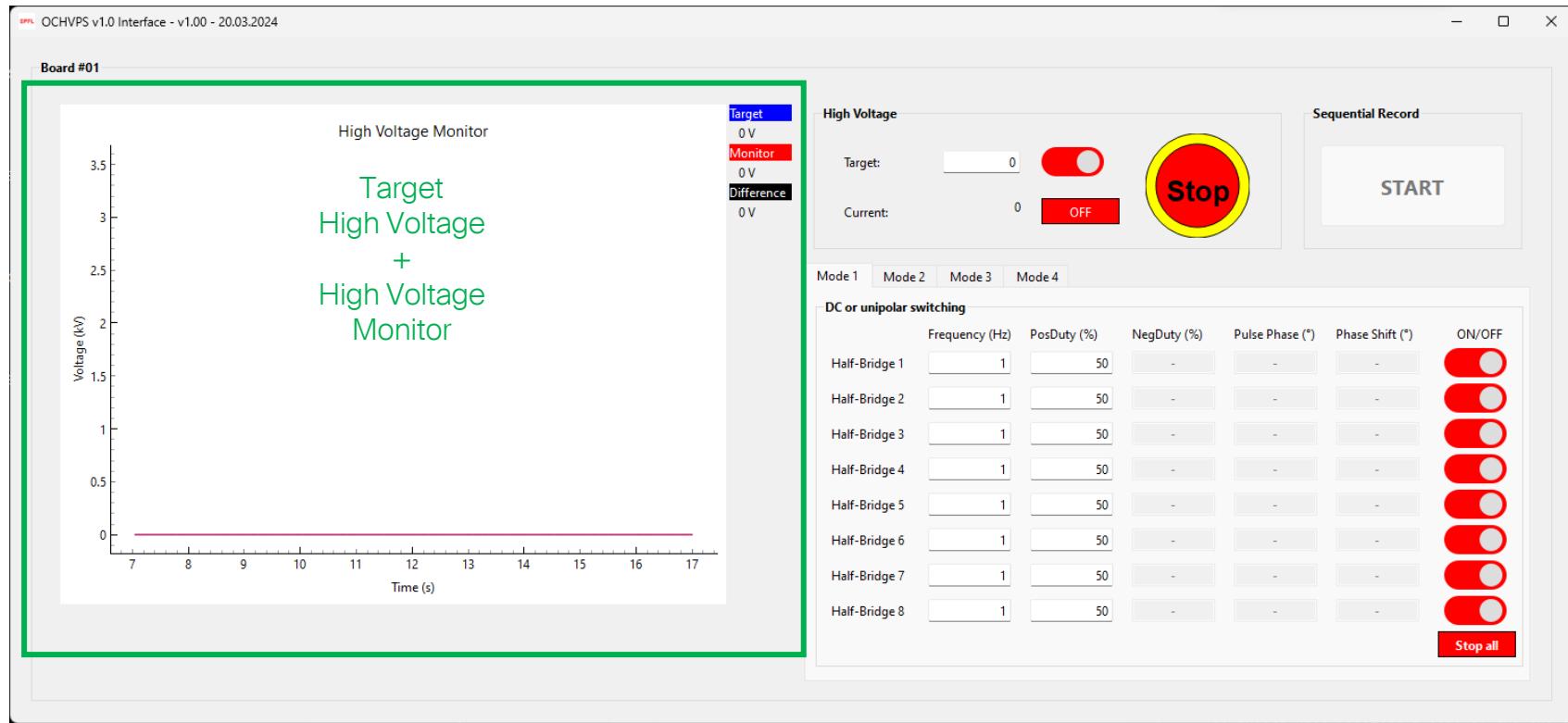
Software – Main window: 1 board and no plot



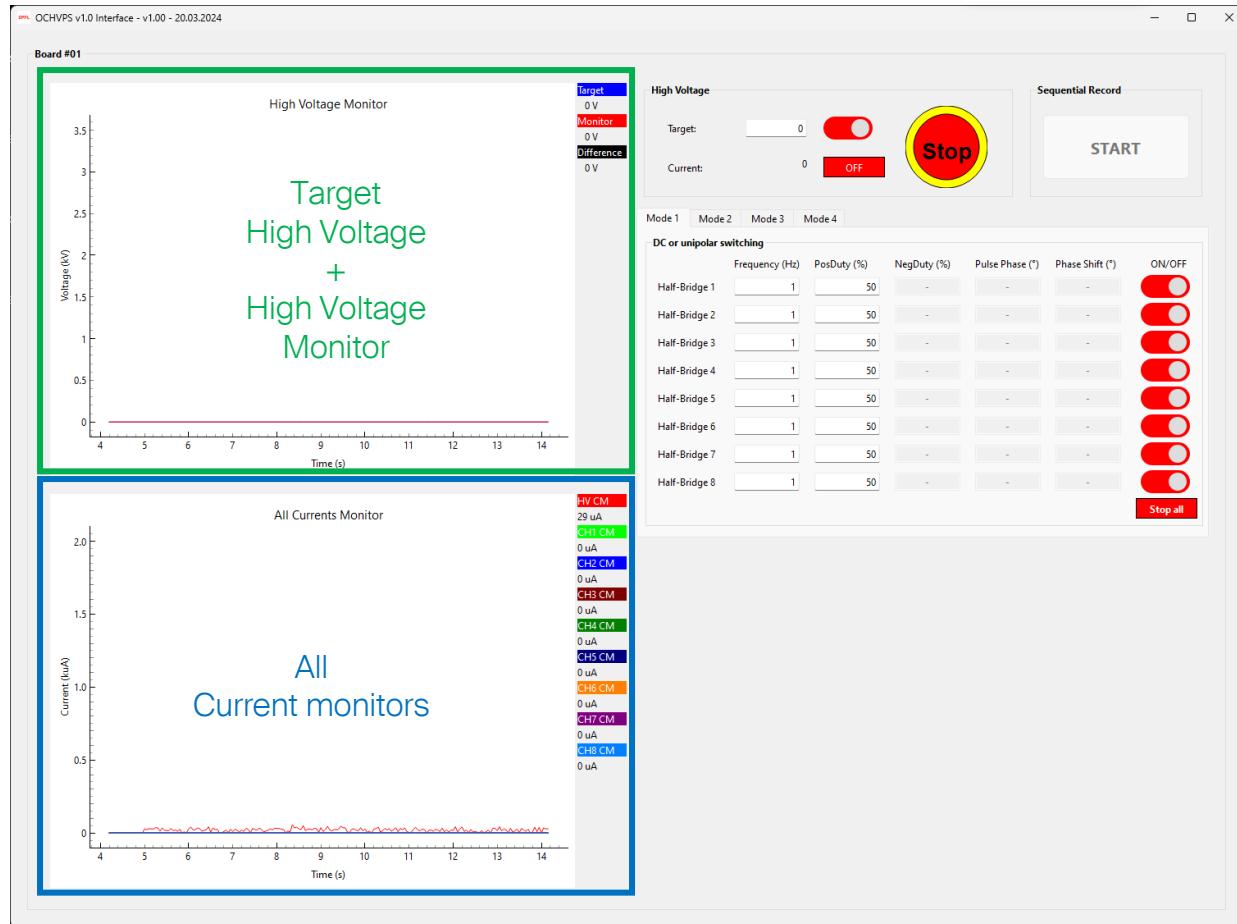
Software – Main window: 1 board and no plot



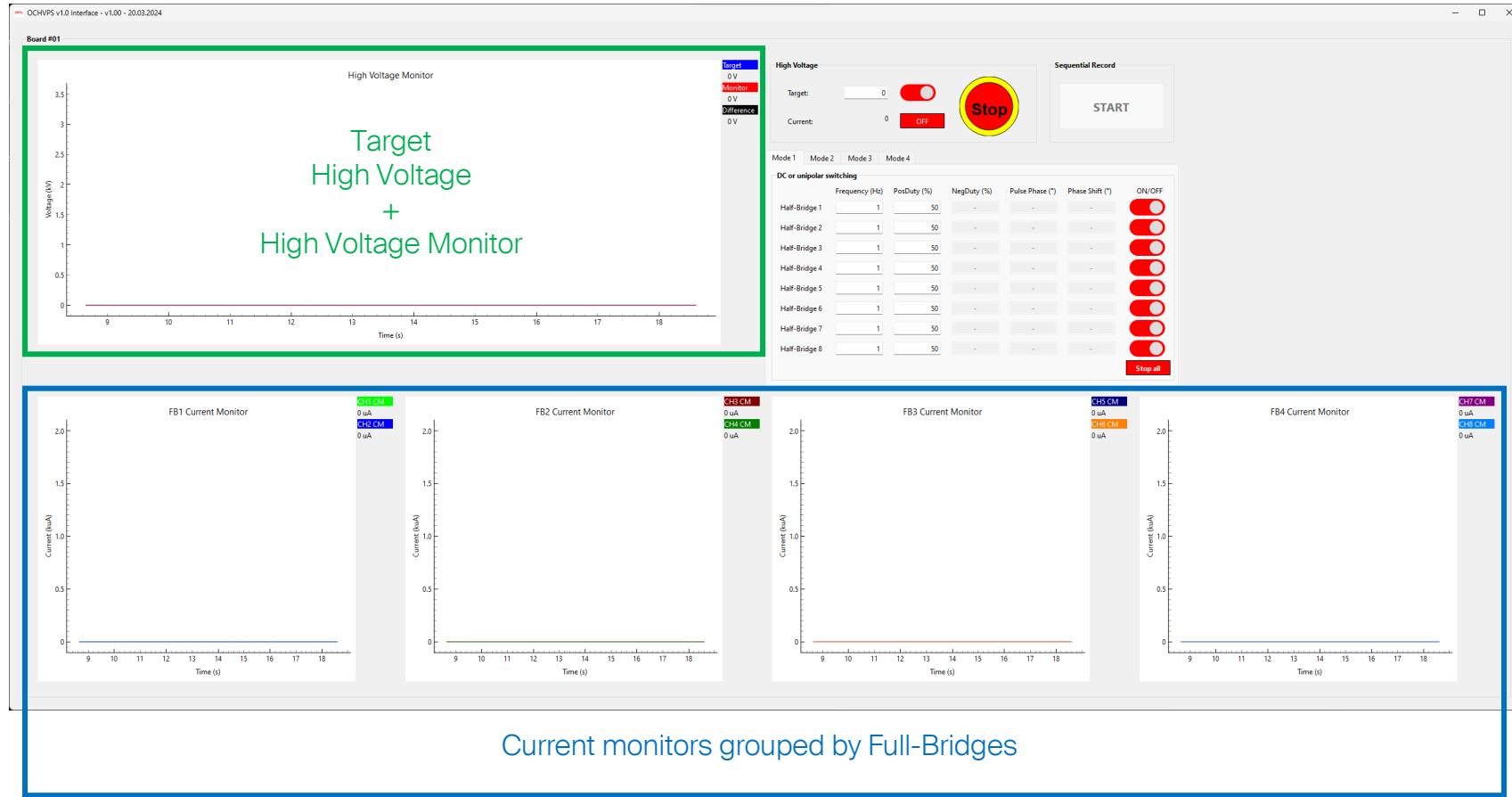
Software – Main window: 1 board with high voltage monitor



Software – Main window: 1 board with voltage and current monitors



Software – Main window: 1 board with voltage and current monitors



Software – Main window: 1 board with voltage and current monitors

